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ABSTRACT

This packet contains teacher and student editions on the topic of equipment systems, intended for the preparation of power product equipment technicians. This publication contains seven units: (1) principles of power transmission; (2) mechanical drive systems; (3) principles of fluid power; (4) hydraulic and pneumatic drive systems; (5) wheel and brake systems; (6) chassis and steering systems; and (7) chassis electrical systems. The materials are based on the curriculum-alignment concept of first stating the objectives, developing instructional strategies for teaching to those objectives, and assessing to those same objectives. Each instructional unit in the teacher edition includes some or all of the following components for each of the four units of instruction: suggested activities, answers to assignment sheets, answers to written test, written test, unit evaluation form, transparency masters, and worksheet masters. The teacher edition also contains information on use of the publication, a competency profile for recording students performance, instructional and task analysis, academic and workplace skill classifications and definitions, and a list of related academic and workplace skills. Each unit in the student edition includes some or all of the following components: objective sheets, information sheet, student supplements, assignment sheets, and job sheets. (KC)

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Equipment Systems

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Equipment Systems

Teacher Edition

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Foreword

Power Product Equipment Technician: Equipment Systems is one in a series of new publications developed to replace MAVCC's previous small-engine series.

Three new publications in the new *Power Product Equipment Technician* series have been developed to replace the core publication for MAVCC's previous small-engine series.

- The first publication, *Theory and Principles of Engine Operation,* is divided into two sections: Section A, "Orientation," and Section B, "Basic Engine Theory and Operation." Section A covers basic workplace safety and first aid, common hand tools, common fasteners, and related math and measuring. Section B addresses reference materials, basic engine principles, engine design and identification, engine operation, and parts management, inventory control, and service orders.

- The second publication, *Engine Systems and Service,* is also divided into two sections: Section A, "Engine Systems," and Section B, "Engine Overhaul." Section A covers lubrication systems, cooling systems, fuel systems, governor systems, basic electrical principles, ignition systems, starting systems, charging systems, and exhaust systems. Section B addresses engine overhaul, troubleshooting, and failure analysis.

- This book, *Equipment Systems,* the third core publication, consists of seven units:

- Unit 1: Principles of Power Transmission
- Unit 2: Mechanical Drive Systems
- Unit 3: Principles of Fluid Power
- Unit 4: Hydraulic and Pneumatic Drive Systems
- Unit 5: Wheel and Brake Systems
- Unit 6: Chassis and Steering Systems
- Unit 7: Chassis Electrical Systems

Three spin-off publications are planned to follow the core materials and complete the new *Power Product Equipment Technician Series: Lawn and Garden Equipment, Construction Equipment,* and *Outboard-Engine Systems and Service.*

Lawn and Garden Equipment will contain an introduction to lawn and garden equipment, a unit on light-duty lawn and garden equipment (walk-behind lawn mowers, edgers, trimmers, dethatchers, blowers, hedge clippers, snow blowers, and pressure washers), a unit on heavy-duty lawn and garden equipment (garden tractors, riding lawn mowers, tillers, log splitters, and shredders), and a unit on chain saws.

Construction Equipment will contain units on concrete equipment (powered concrete mixers, tampers, vibrators, floats, trowels, and screeds), water pumps and air compressors, and alternators, generators, and welding equipment.

Outboard-Engine Systems and Service will contain units on the power head, mid-section, and lower unit of outboard engines as well as units on trailers, boat accessories and rigging, and seasonal service.

These new instructional materials reflect the changes that have occurred in the industry as a result of emerging technology and the demand for more highly skilled workers. The growing need for entry-level workers to be able to read and interpret information provided in manufacturers' service manuals has prompted us to include assignment sheets that teach students how to use reference materials and to create job sheets with worksheets that require students to obtain specific information from a related service manual before completing a specific task.

Today's workers also need a stronger foundation in theoretical concepts and principles to help them better understand how engine systems and equipment components interrelate, and the information sheets and supplements in the student edition have been designed to help provide that foundation.

The success of this publication is due in large part to the capabilities of the personnel who worked with its development. Appreciation is extended to them for their valuable contributions to the publication.

These instructional materials are designed for student use and to assist teachers in organizing and improving instruction. These instructional materials are based on the curriculum-alignment concept of first stating the objectives (objective sheet), developing instructional strategies for teaching to those objectives (information, assignment, and job sheets), and assessing to those same objectives (written test—a criterion-referenced evaluation instrument).

Every effort has been made to make these materials basic, readable, and by all means, usable. However, as with all of MAVCC's instructional materials, teachers must localize and personalize these materials to meet their community, classroom/laboratory, and individual student's situation. Teachers are encouraged to supplement the instructional materials and to develop strategies for motivating their students.

Special attention should be given to the matrix identifying basic academic skills being reinforced in these instructional materials as well as the suggestions on ways to increase reinforcement of academic and workplace skills. By reinforcing these skills, the instructor should assist students in improving their employability skills.

As you use these instructional materials, we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please call or write us.

Sue Ethelbah, Chair Board of Directors Multistate Academic and Vocational Curriculum Consortium, Inc.	Clark R. Harris Executive Director Multistate Academic and Vocational Curriculum Consortium, Inc.

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Appreciation is also extended to Nancy Hilley for providing the original artwork used within this publication and to Mike Barnett, MTD Products Inc. for providing the artwork used on the covers of the student and teacher editions of this publication.

Use of Introductory Materials

Introductory materials are included in the teacher edition only and contain useful information to assist administrators and teachers in planning for instruction.

In addition to the general information—such as the table of contents, foreword, and acknowledgments page—information is included on the following:

1. **Use of this publication**—Explains the components of a unit of instruction and how they should be used as part of the teaching/learning process.

2. **Competency profile**—Provides a record of student performance for each task included in a unit of instruction. This profile becomes a part of the student's permanent records and should be utilized when directing the student toward employment opportunities.

3. **Instructional/task analysis**—Provides a quick review of the contents of the publication; identifies cognitive (knowledge) skills and psychomotor (doing) skills addressed in each unit of instruction.

4. **Academic and workplace skill classifications and definitions**—Defines the basic-skill classifications used by MAVCC. Skill areas reflected by skill groups, subskills, and descriptions have been identified using *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want.* These have been adapted by MAVCC.

5. **Related academic and workplace skills list**—Classifies unit tasks (assignment sheets and job sheets) according to related academic and workplace skills being reinforced.

As you use these materials, it is hoped that they will provide useful information to meet a variety of needs.

Use of This Publication

Instructional units

Power Product Equipment Technician: Equipment Systems contains seven units of instruction:

- Unit 1: Principles of Power Transmission
- Unit 2: Mechanical Drive Systems
- Unit 3: Principles of Fluid Power
- Unit 4: Hydraulic and Pneumatic Drive Systems
- Unit 5: Wheel and Brake Systems
- Unit 6: Chassis and Steering Systems
- Unit 7: Chassis Electrical Systems

Each instructional unit in a student edition includes some or all of the following components: objective sheet, information sheet, student supplements, assignment sheets, and job sheets.

Each section in this teacher edition includes some or all of the following components for each of the seven units of instruction: suggested activities, answers to assignment sheets, answers to written test, written test, unit evaluation form, teacher supplements, transparency masters, and worksheet masters.

All of the unit components focus on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help to determine the following:

- Amount of materials that can be covered in each class period.
- Skills that must be demonstrated.
- Amount of class time needed for teacher demonstrations.
- Amount of time needed for student practice.
- Supplementary materials, including print and nonprint media and equipment and supplies, that must be ordered.
- Resource people who must be contacted.

Student-edition components

It is a challenge to keep students motivated. Instructors should supplement the student-edition components by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each component can best be taught. Allow students to become involved in preparing and planning their teaching/learning experiences.

Objective sheet. Each unit of instruction is based on performance objectives that state the goals for successful completion of the course. These performance objectives are stated in two forms: unit objectives, which state the expected performance of each student after completion of the unit of instruction, and specific objectives, which state what the student must do to reach the unit objective.

Use of This Publication

The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Teachers should prepare for each unit by deciding how each objective can best be taught.

Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information-sheet, assignment-sheet, job-sheet, and written-test items.

Information sheet. The information sheet provides the content essential for meeting the cognitive (knowledge) objectives of the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide information for the teaching of each objective.

Student supplements. The information presented in a student supplement may consist of tables, charts, written information, forms, or other information students will need in order to complete one or more of the assignment sheets or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information is evaluated in the completion of assignment sheets and job sheets.

Assignment sheets. Assignment sheets provide students with pencil-and-paper activities that give students the opportunity to make practical application of the knowledge in the information sheet. Criteria are provided to objectively evaluate student performance.

Job sheets. Job sheets are an important segment of each unit; they give the instructor direction as to the psychomotor skills to be taught and allow both the student and instructor to check student progress toward the accomplishment of those skills. The worksheet included in each job sheet provides criteria to allow the instructor to objectively evaluate student performance of a particular psychomotor skill. The instructor should discuss the equipment and materials to be used—emphasizing the specific equipment and materials available in the classroom and/or laboratory—and demonstrate the job-sheet procedure before having students practice the psychomotor skill.

Teacher-edition components

Suggested activities. The suggested activities assist teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, and a list of supplemental resources. Ways to integrate academic and workplace skills have been included in the teaching suggestions, and skill areas have been noted in bold. The teacher should read the suggested activities before teaching a unit and decide how each objective can best be taught. Time should also be allowed to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the teacher will vary according to the particular unit.

References used in the development of each unit are listed in the suggested-activities section, along with suggested supplemental resources that may be used to teach the unit. These materials can be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or objectives in the area covered.

Assignment-sheet and written-test answers. Assignment-sheet answers and written-test answers are designed to assist the teacher in evaluating student performances on the assignment sheets and written test.

Use of This Publication

Written test. This component is a criterion-referenced evaluation of every cognitive objective listed in the information sheet. If the instructor has added, deleted, or modified objectives, appropriate changes should be made on the written test. It is recommended that the test be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for final tests at the end of each term if desired. The test is included in the teacher edition only, but duplication is permitted for student use.

Unit evaluation form. This form provides teachers with a record of each student's performance on a unit of instruction. It includes space for assignment-sheet ratings, job-sheet ratings, written-test scores, and teacher comments. The unit evaluation form may also be duplicated for student use.

Teacher supplements. Teacher supplements are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student, with remedial information or practice to assist the less-advanced student, and with state-of-the-art information in which the teacher may not have background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

Transparency masters. Transparency masters are used to direct the students' attention to the topic of discussion. Transparency masters may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction.

Worksheet masters. Worksheet masters provide the instructor with masters for making photocopies of the evaluation criteria used to evaluate student performance of the psychomotor skills (job sheets) included in the student edition.

Competency Profile

Name: ____

Directions: Evaluate the student using one of the optional rating scales below. Write the appropriate number/letters to indicate the degree of competency achieved. The descriptions associated with each of the numbers/letters focus on a level of student performance for each of the tasks listed. The written-test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Optional rating scales

Option A

Rating scale:

4 – **Skilled** – Can perform job with no additional training
3 – **Moderately skilled** – Has performed job during training program; limited additional training may be required.
2 – **Limited skill** – Has performed job during training program; additional training is required to develop skill.
1 – **Unskilled** – Is familiar with process, but is unable to perform job.
0 – **No exposure** – No information or practice provided during training program, complete training is required.
NA – **Non-applicable.**

Option B

Yes – Can perform with no additional training
No – Is unable to perform satisfactorily

Unit 1: Principles of Power Transmission

_______ 1. Determine power transmission characteristics of power product equipment
_______ 2. ____

_______Written-test score

Unit 2: Mechanical Drive Systems

_______ 1. Determine mechanical drive-train service specifications and parts requirements
_______ 2. Determine mechanical equipment-drive service specifications and parts requirements
_______ 3. Determine mechanical clutch-system service specifications and parts requirements
_______ 4. Perform routine maintenance on mechanical drive trains
_______ 5. Repair mechanical drive trains
_______ 6. Perform routine maintenance on mechanical equipment drives
_______ 7. Repair mechanical equipment drives
_______ 8. Perform routine maintenance on mechanical clutch systems
_______ 9. Repair mechanical clutch systems
_______10. ____

_______Written-test score

Competency Profile

Unit 3: Principles of Fluid Power

________ 1. Interpret flow diagrams and assembly drawings
________ 2. Measure hydraulic-system temperature
________ 3. Measure hydraulic-system pressure
________ 4. Measure hydraulic-system flow
________ 5. Measure air pressure
________ 6. Measure airflow
________ 7. ____

________Written-test score

Unit 4: Hydraulic and Pneumatic Drive Systems

________ 1. Determine hydraulic and pneumatic drive-system service specifications and parts requirements
________ 2. Perform routine maintenance on hydraulic drive trains
________ 3. Repair hydraulic drive trains
________ 4. Perform routine maintenance on hydraulic equipment drives
________ 5. Repair hydraulic equipment drives
________ 6. Perform routine maintenance on pneumatic equipment drives
________ 7. Repair pneumatic equipment drives
________ 8. ____

________Written-test score

Unit 5: Wheel and Brake Systems

________ 1. Determine tire-and-wheel system service specifications and parts requirements
________ 2. Determine brake-system service specifications and parts requirements
________ 3. Service tires and rims
________ 4. Service wheel bearings and bushings
________ 5. Perform routine maintenance on mechanical brakes
________ 6. Repair mechanical brakes
________ 7. Perform routine maintenance on hydraulic brakes
________ 8. Repair hydraulic brakes
________ 9. Perform routine maintenance on parking brakes
________10. Repair parking brakes
________11. ____

________Written-test score

Unit 6: Chassis and Steering Systems

________ 1. Determine chassis and steering-system service specifications and parts requirements
________ 2. Repair or replace chassis components
________ 3. Perform routine maintenance on mechanical steering systems
________ 4. Repair mechanical steering systems
________ 5. Perform routine maintenance on hydraulic steering systems
________ 6. Repair hydraulic steering systems
________ 7. Perform routine maintenance on drive-wheel steering systems

Competency Profile

Unit 6: **Chassis and Steering Systems** (cont.)

_______ 8. Repair drive-wheel steering systems
_______ 9. ______________________________

_______Written-test score

Unit 7: **Chassis Electrical Systems**

_______ 1. Interpret chassis-electrical-system schematics
_______ 2. Determine chassis-electrical-system service specifications and parts requirements
_______ 3. Perform routine maintenance on chassis electrical systems
_______ 4. Repair chassis electrical systems
_______ 5. Perform routine maintenance on electrical equipment drives
_______ 6. Repair electrical equipment drives
_______ 7. Perform routine maintenance on electromagnetic clutches
_______ 8. Repair electromagnetic clutches
_______ 9. ______________________________

_______Written-test score

Comments: ______________________________

____

____

____

____

Evaluator: ____________________ **Date:** ____________________

Permission to duplicate this profile is granted.

Instructional/Task Analysis

Related information: What the student should know	Application: What the student should be able to do
Unit 1: Principles of Power Transmission	
1. Basic concepts of physics related to power transmission	14. Determine power-transmission characteristics of power product equipment
2. Definitions of the types of power-transmission systems	
3. Definition of the term *drive system*	
4. Functions of the types of drive systems used in power product equipment	
5. Function of a clutch in a drive system	
6. Types of drive trains used in power product equipment	
7. Characteristics used to classify drive trains	
8. Definitions of the types of output configurations used in drive trains	
9. Types of equipment drives used in power product equipment	
10. Functions of the major components of an equipment drive	
11. Descriptions of the types of clutch systems	
12. Functions of the major components of a clutch system	
13. Devices used to actuate clutches	
Unit 2: Mechanical Drive Systems	
1. Types of belts used in mechanical drive systems	
2. Types of chains used in mechanical drive systems	
3. Types of gears used in mechanical drive systems	
4. Descriptions of the types of shafts used in mechanical drive systems	

Related information: What the student should know	Application: What the student should be able to do
Unit 2: Mechanical Drive Systems (cont.)	
5. Types of mechanical drive trains	
6. Functions of the major components of belt drive trains	
7. Principles of operation of belt drive trains	
8. Functions of the major components of gear drive trains	
9. Principles of operation of gear drive trains	
10. Types of mechanical equipment drives	
11. Principles of operation of mechanical-PTO equipment drives	
12. Principles of operation of ground-drive equipment drives	
13. Typical service procedures required for belt drive systems	
14. Typical service procedures required for chain drive systems	
15. Typical service procedures required for gear drive systems	
16. Typical service procedures required for shaft drive systems	
17. Types of mechanical clutch systems	
18. Principles of operation of belt clutch systems	
19. Principles of operation of jaw clutch systems	
20. Principles of operation of friction clutch systems	
21. Principles of operation of centrifugal clutch systems	
22. Principles of operation of multi-disc clutch systems	

Related information: What the student should know	Application: What the student should be able to do
Unit 2: Mechanical Drive Systems (cont.)	
23. Safety rules for working with mechanical clutch systems	25. Determine mechanical drive-train service specifications and parts requirements
24. Typical service procedures required for mechanical clutch systems	26. Determine mechanical equipment-drive service specifications and parts requirements
	27. Determine mechanical clutch-system service specifications and parts requirements
	28. Perform routine maintenance on mechanical drive trains
	29. Repair mechanical drive trains
	30. Perform routine maintenance on mechanical equipment drives
	31. Repair mechanical equipment drives
	32. Perform routine maintenance on mechanical clutch systems
	33. Repair mechanical clutch systems
Unit 3: Principles of Fluid Power	
1. Basic concepts of physics related to fluid-power transmission	
2. Descriptions of the types of fluid-power systems commonly used in power product equipment	
3. Functions of the major components of hydraulic systems	
4. Common symbols used on hydraulic diagrams	
5. Descriptions of the types of hydraulic fluids used in power product equipment	
6. Safety rules for working with hydraulic systems	

Instructional/Task Analysis

Related information: What the student should know	Application: What the student should be able to do
Unit 3: Principles of Fluid Power (cont.)	
7. Guidelines for preventing equipment damage when working with hydraulic systems	
8. Types of power product equipment that use hydraulic power	
9. Applications of hydraulic systems in power product equipment	
10. Types of hydraulic pumps	
11. Functions of the major components of hydraulic pumps	
12. Principles of operation of centrifugal hydraulic pumps	
13. Principles of operation of rotary hydraulic pumps	
14. Principles of operation of diaphragm hydraulic pumps	
15. Principles of operation of piston hydraulic pumps	
16. Typical service procedures required for hydraulic systems	
17. Specialty tools used to perform hydraulic-system service	
18. Functions of the major components of pneumatic systems	
19. Common symbols used on pneumatic diagrams	
20. Safety rules for working with pneumatic systems	
21. Guidelines for preventing equipment damage when working with pneumatic systems	
22. Types of power product equipment that use pneumatic power	

Instructional/Task Analysis

Related information: What the student should know	Application: What the student should be able to do
Unit 3: Principles of Fluid Power (cont.)	
23. Applications of pneumatic systems in power product equipment	32. Interpret flow diagrams and assembly drawings
24. Types of pneumatic pumps	33. Measure hydraulic-system temperature
25. Functions of the major components of pneumatic pumps	34. Measure hydraulic-system pressure
	35. Measure hydraulic-system flow
26. Principles of operation of centrifugal pneumatic pumps	36. Measure air pressure
27. Principles of operation of propeller pneumatic pumps	37. Measure airflow
28. Principles of operation of diaphragm pneumatic pumps	
29. Principles of operation of reciprocating pneumatic pumps	
30. Typical service procedures required for pneumatic systems	
31. Specialty tools used to perform pneumatic-system service	
Unit 4: Hydraulic and Pneumatic Drive Systems	
1. Descriptions of the types of clutches used with hydraulic and pneumatic drive systems	
2. Descriptions of the types of hydraulic drive trains used in power product equipment	
3. Functions of the major components of hydrostatic drive trains	
4. Principles of operation of hydrostatic drive trains	
5. Principles of operation of axial-piston hydraulic pumps	
6. Principles of operation of radial-piston hydraulic pumps	

Related information: What the student should know	Application: What the student should be able to do
Unit 4: Hydraulic and Pneumatic Drive Systems (cont.)	
7. Types of hydrostatic drive trains as classified by their pump and motor designs 8. Principles of operation of hydraulic equipment drives 9. Typical service procedures required for hydraulic drive systems 10. Types of pneumatic power used to accomplish work in power product equipment 11. Functions of the major components of pneumatic drive systems 12. Principles of operation of pneumatic equipment drives 13. Typical service procedures required for pneumatic drive systems	14. Determine hydraulic and pneumatic drive-system service specifications and parts requirements 15. Perform routine maintenance on hydraulic drive trains 16. Repair hydraulic drive trains 17. Perform routine maintenance on hydraulic equipment drives 18. Repair hydraulic equipment drives 19. Perform routine maintenance on pneumatic equipment drives 20. Repair pneumatic equipment drives
Unit 5: Wheel and Brake Systems	
1. Functions of the major components of tire and wheel assemblies 2. Descriptions of the types of tires used in power product equipment 3. Types of rims used in tire and wheel assemblies 4. Types of wheel supports used in tire and wheel assemblies 5. Typical service procedures required for tire and wheel assemblies 6. Uses of the specialty tools used in tire and wheel service 7. Safety rules for performing tire and wheel service 8. Definitions of the types of brake systems used in power product equipment	

Related information: What the student should know	Application: What the student should be able to do

Unit 5: Wheel and Brake Systems (cont.)

9. Functions of the major components of mechanical brake systems	20. Determine tire-and-wheel system service specifications and parts requirements
10. Descriptions of the types of mechanical brake systems	21. Determine brake-system service specifications and parts requirements
11. Principles of operation of mechanical brake systems	22. Service tires and rims
12. Typical service procedures required for mechanical brake systems	23. Service wheel bearings and bushings
13. Functions of the major components of hydraulic brake systems	24. Perform routine maintenance on mechanical brakes
14. Principles of operation of hydraulic brake systems	25. Repair mechanical brakes
15. Descriptions of types of disc- and drum-brake hydraulic-cylinder designs	26. Perform routine maintenance on hydraulic brakes
16. Typical service procedures required for hydraulic brake systems	27. Repair hydraulic brakes
17. Safety rules for performing brake-system repair	28. Perform routine maintenance on parking brakes
18. Types of parking brakes used in power product equipment	29. Repair parking brakes
19. Typical service procedures required for parking brakes	

Unit 6: Chassis and Steering Systems

1. Functions of the major components of chassis	
2. Typical service procedures required for chassis	
3. Types of steering systems used in power product equipment	
4. Types of steering-system configurations used in power product equipment	

Related information: What the student should know	Application: What the student should be able to do
Unit 6: Chassis and Steering Systems (cont.)	
5. Functions of the major components of steering systems	8. Determine chassis and steering-system service specifications and parts requirements
6. Principles of operation of the types of gears used in steering systems	9. Repair or replace chassis components
7. Typical service procedures required for steering systems	10. Perform routine maintenance on mechanical steering systems
	11. Repair mechanical steering systems
	12. Perform routine maintenance on hydraulic steering systems
	13. Repair hydraulic steering systems
	14. Perform routine maintenance on drive-wheel steering systems
	15. Repair drive-wheel steering systems
Unit 7: Chassis Electrical Systems	
1. Definitions of terms associated with electrical systems	
2. Functions of the major components of chassis electrical systems	
3. Functions of the types of safety shutoff devices used in chassis electrical systems	
4. Functions of the types of personal-safety shutoff devices	
5. Functions of the types of equipment-safety shutoff devices	
6. Descriptions of the types of lights used in chassis electrical systems	
7. Typical service procedures required for chassis electrical systems	
8. Principles of operation of electric equipment drives	

Related information: What the student should know	Application: What the student should be able to do
Unit 7: Chassis Electrical Systems (cont.)	
9. Typical service procedures required for electric equipment drives	15. Interpret chassis-electrical-system schematics
10. Major components of electromagnetic clutches	16. Determine chassis-electrical-system service specifications and parts requirements
11. Principles of operation of electromagnetic clutches	17. Perform routine maintenance on chassis electrical systems
12. Typical service procedures required for electromagnetic clutches	18. Repair chassis electrical systems
13. Common symbols used on electrical schematics	19. Perform routine maintenance on electrical equipment drives
14. Functions of the specialty instruments used in electrical-system repair	20. Repair electrical equipment drives
	21. Perform routine maintenance on electromagnetic clutches
	22. Repair electromagnetic clutches

Academic and Workplace Skill Classifications and Definitions

Skill group	Subskill	Definition
Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task.
	Writing	Communicating a thought, idea, or fact in written form in a clear, concise manner.
	Arithmetic/ mathematics	Performing basic computations, applying estimating and reasoning skills, and solving practical problems using a variety of mathematical techniques.
	Science	Applying knowledge learned through study and practice that is based on scientific principles, methods, and techniques.
	Listening	Receiving, interpreting, and responding to verbal messages and other cues.
	Speaking	Communicating a thought, idea, or fact verbally in a clear, concise manner.
Thinking skills	Creative thinking	Using imagination to generate new ideas.
	Decision making	Specifying goals and constraints, generating alternatives, considering risks, and evaluating and choosing the best alternative.
	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results.
	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information.
	Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills.
	Reasoning	Applying a rule or principle underlying the relationship between two or more objects when solving a problem.
Personal-management skills	Responsibility	Exerting a high level of effort towards goal attainment, working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration.
	Self-esteem	Developing self-confidence and maintaining a positive view of self.
	Career awareness, development, and mobility	Assessing self accurately, setting personal goals, establishing and implementing a plan, and monitoring progress.
	Integrity/honesty	Choosing an ethical course of action when faced with making a decision that may break with personal or societal values and recognizing the impact of violating these beliefs and codes on an organization, self, and others.
	Organizational effectiveness	Adapting to the organization's goals, values, culture, and traditional modes of operation.

Academic and Workplace Skill Classifications and Definitions

Skill group	Subskill	Definition
Interpersonal skills	Teamwork	Working cooperatively with others to reach a common goal.
	Coaching	Helping others learn new skills.
	Leadership	Communicating ideas to justify position; accepting responsibility for others; and encouraging, persuading, convincing, or otherwise motivating an individual or group.
	Negotiation	Resolving conflict between two or more individuals through discussion and compromise.
	Customer service	Working and communicating with customers to satisfy their expectations.
	Cultural diversity	Working well with men and women and with a variety of ethnic, social, or educational backgrounds.
Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources or creating it, and evaluating its relevance and accuracy.
	Organization and storage	Organizing, processing, and maintaining written or computerized records and other forms of information in a systematic way.
	Interpretation	Selecting and analyzing information and communicating the results to others.
	Processing	Using computers to acquire, organize, analyze, and communicate information.
Systems	Interrelationships	Knowing how social, organizational, and technological systems work and operate effectively.
	Monitoring	Distinguishing trends, predicting impact of actions on system operations, diagnosing deviations in systems' performance, and correcting malfunctions.
	Modification and design	Making suggestions to modify existing systems to improve products or services, and developing new or alternative systems.
Technology	Selection	Choosing procedures, tools, or equipment including computers and related technologies.
	Application	Demonstrating proper procedures for setting up and operating equipment.
	Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment, including computers and other technologies.
Resources	Time	Selecting relevant, goal-related activities, ranking them in order of importance, allocating time, and understanding, preparing, and following schedules.
	Money	Using or preparing budgets, making forecasts, keeping records, and making adjustments to meet objectives.
	Material and facilities	Acquiring, storing, and using materials and space efficiently.
	Human resources	Assessing skills and distributing work accordingly; evaluating performance and providing feedback.

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 1: Principles of Power Transmission			
Determine power transmission characteristics of power product equipment (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Unit 2: Mechanical Drive Systems			
Determine mechanical drive-train service specifications and parts requirements (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Determine mechanical equipment-drive service specifications and parts requirements (A.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Determine mechanical clutch-system service specifications and parts requirements (A.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task

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Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 2: Mechanical Drive Systems (cont.)			
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Perform routine maintenance on mechanical drive trains (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair mechanical drive trains (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 2: Mechanical Drive Systems (cont.)			
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on mechanical equipment drives (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 2: Mechanical Drive Systems (cont.)			
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair mechanical equipment drives (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on mechanical clutch systems (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 2: Mechanical Drive Systems (cont.)			
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair mechanical clutch systems (J.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 3: Principles of Fluid Power			
Interpret flow diagrams and assembly drawings (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Measure hydraulic-system temperature (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Measure hydraulic-system pressure (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task

Task	Skill group	Subskill	Definition
Unit 3: Principles of Fluid Power (cont.)			
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Measure hydraulic-system flow (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 3: Principles of Fluid Power (cont.)			
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Measure air pressure (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Measure airflow (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results

Task	Skill group	Subskill	Definition
Unit 3: Principles of Fluid Power (cont.)			
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Unit 4: Hydraulic and Pneumatic Drive Systems			
Determine hydraulic and pneumatic drive-system service specifications and parts requirements (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Perform routine maintenance on hydraulic drive trains (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results

Task	Skill group	Subskill	Definition
Unit 4: Hydraulic and Pneumatic Drive Systems (cont.)			
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair hydraulic drive trains (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment

Task	Skill group	Subskill	Definition
Unit 4: Hydraulic and Pneumatic Drive Systems (cont.)			
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on hydraulic equipment drives (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair hydraulic equipment drives (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 4: Hydraulic and Pneumatic Drive Systems (cont.)			
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on pneumatic equipment drives (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair pneumatic equipment drives (J.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 4: Hydraulic and Pneumatic Drive Systems (cont.)			
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Unit 5: Wheel and Brake Systems			
Determine tire-and-wheel system service specifications and parts requirements (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Determine brake-system service specifications and parts requirements (A.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 5: Wheel and Brake Systems (cont.)			
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Service tires and rims (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Service wheel bearings and bushings (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 5: Wheel and Brake Systems (cont.)			
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on mechanical brakes (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 5: Wheel and Brake Systems (cont.)			
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair mechanical brakes (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on hydraulic brakes (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 5: Wheel and Brake Systems (cont.)			
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair hydraulic brakes (J.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on parking brakes (J.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 5: Wheel and Brake Systems (cont.)			
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair parking brakes (J.S. 8)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 5: Wheel and Brake Systems (cont.)			
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Unit 6: Chassis and Steering Systems			
Determine chassis and steering-system service specifications and parts requirements (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Repair or replace chassis components (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 6: Chassis and Steering Systems (cont.)			
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on mechanical steering systems (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair mechanical steering systems (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 6: Chassis and Steering Systems (cont.)			
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on hydraulic steering systems (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair hydraulic steering systems (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 6: Chassis and Steering Systems (cont.)			
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on drive-wheel steering systems (J.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition

Unit 6: Chassis and Steering Systems (cont.)

Task	Skill group	Subskill	Definition
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair drive-wheel steering systems (J.S. 7)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment

Unit 7: Chassis Electrical Systems

Task	Skill group	Subskill	Definition
Interpret chassis-electrical-system schematics (A.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 7: Chassis Electrical Systems (cont.)			
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Determine chassis-electrical-system service specifications and parts requirements (A.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Seeing things in the mind's eye	Mentally organizing and processing symbols, pictures, graphs, and other information
		Knowing how to learn	Using efficient learning techniques to acquire and apply new knowledge and skills
	Information	Interpretation	Selecting and analyzing information and communicating the results to others
Perform routine maintenance on chassis electrical systems (J.S. 1)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment

Task	Skill group	Subskill	Definition
Unit 7: Chassis Electrical Systems (cont.)			
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair chassis electrical systems (J.S. 2)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Perform routine maintenance on electrical equipment drives (J.S. 3)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 7: Chassis Electrical Systems (cont.)			
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair electrical equipment drives (J.S. 4)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 7: Chassis Electrical Systems (cont.)			
Perform routine maintenance on electromagnetic clutches (J.S. 5)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment
Repair electromagnetic clutches (J.S. 6)	Basic skills	Reading	Comprehending written information and analyzing, summarizing, and applying what has been read to a specific task
		Writing	Communicating a fact in written form in a clear, concise manner
	Thinking skills	Problem solving	Recognizing and defining problems, devising and implementing a plan of action, and tracking and evaluating results
	Personal-management skills	Responsibility	Working hard to become excellent at doing tasks by setting high standards, paying attention to details, and displaying a high level of concentration
	Resources	Material and facilities	Acquiring, storing, and using materials and space efficiently
	Information	Acquisition and evaluation	Identifying need for data, obtaining it from existing sources, and evaluating its relevance and accuracy

Related Academic and Workplace Skills List

Task	Skill group	Subskill	Definition
Unit 7: Chassis Electrical Systems (cont.)			
		Interpretation	Selecting and analyzing information and communicating the results to others
	Systems	Interrelationships	Knowing how technology systems work and operate effectively
	Technology	Selection	Choosing procedures, tools, or equipment
		Application	Demonstrating proper procedures for setting up and operating equipment
		Maintenance and troubleshooting	Preventing, identifying, or solving problems with equipment

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Principles of Power Transmission
Unit 1

Suggested Activities

Instructional plan

Preparation

- Review the unit in the student edition and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Prepare the classroom by displaying posters, equipment, and tools related to power-transmission principles.

- Make transparencies from the transparency masters included in the teacher pages of this unit.

- Select teacher components (written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution.

Delivery and application

Unit introduction

The skill areas appearing in bold-face type in the unit introduction and teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want*. These have been adapted by MAVCC.

- Introduce yourself to the class and provide your students with some information about your background and qualifications. Allow the students to introduce themselves, discuss their backgrounds, and explain why they are enrolled in the course.

  Discuss the course format, your policies, and the facility. Explain the concept of competency-based education and the design of the materials. If your students are familiar with your approach and with MAVCC materials from previous courses, tailor your explanation to their needs.

  (Listening; oral communication; adapting to the organization's traditional modes of operation; emphasizing personal and career development)

Suggested Activities

- Provide the students with the student edition of this unit. You may choose to begin by discussing the objective sheet or all student materials. Review the unit and specific objectives with the students. Discuss how meeting the unit objective will improve their employability or will increase their value as an employee. Explain how the specific objectives support the unit objective. **(Reading; listening; adapting to the organization's traditional modes of operation)**

Teaching suggestions

Objective 1 Complete statements concerning the basic concepts of physics related to power transmission.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Point out to the students that the purpose of power product equipment is to produce power, control it, and direct it so that work can be done. Discuss the fact that the production and control of power operates in accordance with certain physical principles referred to as *laws of physics*. Explain that a technician's ability to analyze equipment performance and to effect repairs and service depends on his or her ability to understand and apply these physical laws. Demonstrate these laws, displaying matter and energy and the three states of matter. Show conversions of energy and the application of force to change the shape and motion of matter. Use a torque wrench, spring scales, or other instruments that can measure force and power. Demonstrate the transmission of power and different types of energy. **(Listening; reading; science; seeing things in the mind's eye)**

Objective 2 Define the types of power-transmission systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Provide examples of the various types of power-transmission systems and demonstrate how power is transmitted through these systems. Discuss applications of such systems in power product equipment. Include examples of both drive trains and equipment drives as a foundation for the later objectives. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Objective 3 Define the term *drive system*.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Relate the previous two objectives to the application of power to perform work. Demonstrate the operation of both equipment drives and drive trains. Show a variety of power-transmission methods. Discuss such applications in a variety of types of equipment. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

Objective 4 State the functions of the types of drive systems used in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Recall the demonstrations for the previous objective to classify each as a drive train or an equipment drive. Simplify the discussion by showing one piece of equipment that uses only an equipment drive, such as a chain saw or string trimmer, and a second piece of equipment that uses power primarily for the drive train, such as a motorcycle, golf cart, or snowmobile. Make sure the students understand these power trains and then introduce them to equipment that uses power transmission for both equipment-drive and drive-train applications. **(Listening; reading; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 5 State the function of a clutch in a drive system.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Point out the clutches used in the power-transmission systems presented in the previous demonstrations. Show how the clutches control power transmission. Demonstrate the operation of the major types of systems. Relate the complexity, cost, and similar characteristics of each type of design and operation to its suitability for specific applications. Point out the major areas of wear and requirements for periodic maintenance associated with each design. Describe similarities and differences in the operation of each design based on applications, such as differences for equipment-drive applications versus drive-train applications or a belt clutch system on a riding lawn mower versus a tiller. Ensure that the students fully understand the terms *engage* and *disengage* as applicable to clutch systems. **(Listening; reading; reasoning; seeing things in the mind's eye; system interrelationships)**

- Discuss the need to operate the engine on power product equipment without loading it, the need to move self-propelled equipment without operating power-take-off attachments, and the need to operate attachments without moving self-propelled equipment. Point out from the examples that many types of power product equipment are likely to have more than one clutch—an equipment-drive clutch and a drive-train system. Use a piece of equipment to point out these two clutch systems, to support this objective, and to lead into the next objective. If possible, use a piece of equipment that has more than one equipment drive, such as a PTO and mower deck. **(Listening; speaking; reasoning; applying technology; seeing things with the mind's eye; system interrelationships)**

Objective 6 List the types of drive trains used in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

Suggested Activities

- Use illustrations and actual equipment to describe the operation of mechanical, hydraulic, and hydrostatic drive trains. Discuss how the operation of each type of system makes it suitable or unsuitable for specific applications. For example, a direct-gear system may be efficient and durable, but such a system is likely to be too complex, heavy, and expensive if on a small riding lawn mower. **(Listening; reading; science; seeing things in the mind's eye; system interrelationships)**

Objective 7 List the characteristics used to classify drive trains.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use illustrations to provide examples of each characteristic discussed in the objective. Use a variety of designs. For example, show both single- and multiple-speed gear systems, belt drives that are capable of only forward motion and those that can produce forward or reverse motion, and transmissions and transaxles that use various drive mechanisms. Provide an overview of applications and associated service procedures for each type. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Objective 8 Distinguish between the definitions of the types of output configurations used in drive trains.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Increase the detail of your discussion of drive-train operation by discussing the components of a typical drive train and the functioning of those components. Use Transparency 1, "Types of Output Configurations Used in Drive Trains," and other illustrations to aid the discussion. Provide actual examples of various types of drive trains and relate the operation of each to the others. For example, show how gears, shafts, chains, and belts can be used to perform similar functions. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Objective 9 List the types of equipment drives used in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use illustrations as well as actual equipment to assist with the discussion. Demonstrate the design and operation of each type of system. Point out similarities and differences. Discuss the advantages and disadvantages of each in specific applications and describe common applications of each type. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

Objective 10 State the functions of the major components of an equipment drive.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Demonstrate the operation of various equipment drives. Point out the corresponding components for the various systems and explain how they accomplish the described function. Discuss mechanical principles at work in the operation of each type of equipment drive. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Objective 11 Match types of clutch systems to their correct descriptions.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use illustrations as well as actual equipment to assist with the discussion. Demonstrate the design and operation of each type of system. Point out similarities and differences. Discuss the advantages and disadvantages of each in specific applications and describe common applications of each type. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Objective 12 State the functions of the major components of a clutch system.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use Transparency 2, "Major Components of a Clutch System," and other illustrations to assist with the discussion. Demonstrate the operation of various types of clutches. Point out the corresponding components for the various systems and explain how they accomplish the described function. Discuss mechanical principles at work in the operation of each type of clutch. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Objective 13 List devices used to actuate clutches.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use illustrations as well as actual equipment to describe methods for actuating clutch systems. Discuss the importance of proper clutch actuation in terms of wear, equipment damage, safety, etc., and concepts such as "riding" a clutch or improper belt tension. Point out that equipment with more than one clutch system is likely to have more than one actuation method. Relate the various methods to specific applications and discuss why one method may be preferable to another in specific applications. **(Listening; reading; science; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

- Demonstrate different actuation devices and allow the students to operate these systems so that they will get a feel for how each operates. Through discussion or demonstration, help the students to understand what to look for in defective clutch operation, such as inadequate belt engagement, weak springs, etc. **(Listening; reading; science; seeing things in the mind's eye; system interrelationships)**

Assignment Sheet 1 Determine power-transmission characteristics of power product equipment.

- Have students locate Assignment Sheet 1. Read the introduction and directions to the assignment. **(Reading/listening for content)**
- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Listening; reading; writing; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**
- Answer any student questions and have students complete Assignment Sheet 1.

Evaluation

- Evaluate the assignment sheet. See the evaluation criteria listed at the top of the assignment sheet as well as the teacher page "Answers to Assignment Sheet."
- Give the written test. See the teacher page "Written Test."
- Evaluate the written test. See the teacher page "Answers to Written Test."
- Compile written-test and assignment-sheet scores. See the teacher page "Unit Evaluation Form."
- Reteach and retest as required.

Suggested resources

Resources used in developing this unit

Print media

- Graf, Rudolf F., and George J. Whalen. *VNR Illustrated Guide to Power Tools.* New York: Van Nostrand Reinhold Company, 1978.
- Hawker, M. F. J., and J. F. Keenlyside. *Horticultural Machinery,* 3rd ed. Essex, England: Longman Group Limited, 1985.
- Hedges, Charles S. *Industrial Fluid Power,* 3rd ed. Dallas, Texas: Womack Educational Publications, 1984.
- Jorgensen, Eric, editor. *Kawasaki 250-750cc Triples,* 5th ed. Arleta, California: Clymer Publications, 1979.

- *MTD Yard-Man Technical Service Handbook.* Cleveland, Ohio: MTD Products, Inc., 1996.
- *Outdoor Power Equipment Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1985.
- *Power Tools and Equipment.* Alexandria, Virginia: Time-Life Books, Inc., 1989.
- *Power Trains: Compact Equipment.* Moline, Illinois: Deere and Company, 1991.
- *Riding Lawn Mower Service Manual,* 4th ed. Overland Park, Kansas: Intertec Publishing Corporation, 1993.
- *Small Tractor Service Manual.* Overland Park, Kansas: Intertec Publishing Corporation, 1984.
- Stewart, Harry L. *Hydraulics for Off-the-Road Equipment.* Indianapolis, Indiana: Theodore Audel and Co., 1978.
- Wright, Ron. *Harley-Davidson Sportsters,* 7th ed. Arleta, California: Clymer Publications, 1986.
- *Yard and Garden Tractor Service Manual,* 1st ed. Overland Park, Kansas: Intertec Publishing Corporation, 1992.

Suggested supplemental resources

Print media

- *Outdoor Power Equipment* magazine. Adams/Green Industry Publishing, 68860 Perez Road, Suite J, Cathedral City, California 92234. Web site: http://www.outdoorpowerequipment.com
- *Power Equipment Trade* magazine. Hatton-Brown Publishers, Inc., P. O. Box 2268, Montgomery, Alabama 36102.
- *Technical Handbook.* Describes the makes and types of equipment produced by MTD—one of the nation's largest manufacturers. The book covers service for most equipment systems and various types of equipment. Both light- and heavy-duty equipment types are included. Available from MTD Products, Inc. Call 1-800-422-3381.
- Service manuals for systems covered in this unit.
- Parts catalogs for systems covered in this unit. Available from equipment manufacturers.

Non-print media

- *The Physical World of a Machine.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (615) 624-2628.
- *Roller Chain.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (615) 624-2628.

Suggested Activities

- *Single Speed Transmission Theory, Disassembly and Repair.* This videotape describes the operation and service of single-speed transmissions with integrated differentials used in numerous products. Available from MTD Products, Inc. Call 1-800-422-3381.
- *V-Belts.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (615) 624-2628.

Principles of Power Transmission
Unit 1

Answers to Assignment Sheet

Assignment Sheet 1—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1.
   a. Hydrostatic
   b. Yes
   c. Transmission
   d. Variable speed
   e. Electric PTO
   f. PTO switch

2.
   a. Mechanical
   b. Yes
   c. Transaxle
   d. Four forward, one reverse
   e. Traction belt
   f. Pedal

3.
   a. Mechanical
   b. Yes
   c. Transaxle
   d. SAE 10W30 oil; 2.54 quarts (2.4 liters)
   e. Friction plate
   f. Pedal

4.
   a. Belt tensioner
   b. Belt
   c. Chain
   d. Two-step engine pulley
   e. Lever

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Principles of Power Transmission
Unit 1

Answers to Written Test

1.
   a. matter, energy
   b. solid, liquid, gas
   c. heat, light, electrical energy, chemical energy, mechanical energy, nuclear energy
   d. matter
   e. work
   f. force
   g. power
   h. transmission

2.
   a. System that uses belts, pulleys, chains, shafts, and similar linkages to transmit power
   b. System that uses liquid to transmit power
   c. System that uses air or other gases to transmit power
   d. System that uses electricity to transmit power
   e. System that uses the properties of magnetism to transmit power

3. Generic term applied to any collection of components that transmit power from an engine to a point where work is done

4.
   a. Provides the force that allows the equipment to move under its own power
   b. Provides the force that powers those attachments that accomplish the work performed by the equipment

5. Controls the transmission of power from the engine to a drive system

6. Answers may appear in any order.

   - Mechanical
   - Hydraulic
   - Hydrostatic

7. Answers may appear in any order.

   - Method of power transmission
   - Drive-direction capabilities
   - Output configuration
   - Number of speeds

8.
   a. A
   b. T

Answers to Written Test

9. Answers may appear in any order.

- Mechanical power take-off (mechanical PTO)
- Hydraulic PTO
- Pneumatic
- Electric
- Ground drive

10. a. Provides the input power necessary to operate the equipment drive
    b. Engages or disengages the equipment drive
    c. Converts input power to a form usable by the equipment
    d. Transmits power from the equipment drive to the equipment

11. a. 3
    b. 2
    c. 4
    d. 1

12. a. Allows the operator to engage or disengage the clutch, or provides automatic control of the clutch
    b. Delivers power from the engine
    c. Provides the physical connection between the engine-input linkage and the clutch output
    d. Transfers power to the drive system
    e. Returns the clutch to its normal position when the actuator is released

13. Answers may appear in any order.

- Pedal
- Lever
- Switch
- Automatic actuating devices

Principles of Power Transmission
Unit 1

Written Test

Name ______________________________ Score ______________

1. Complete statements concerning the basic concepts of physics related to power transmission. Write the correct word(s) on the blanks provided in the statements below.

   a. The universe consists of two components: (1) those things that take up space—known as ____________________—and (2) movement or the ability to produce movement—known as ____________________.

   b. Matter commonly occurs in one of three states on earth: (1) a ____________________, (2) a ____________________, or (3) a ____________________.

   c. Energy occurs in many forms, such as ____________________, ____________________, ____________________, ____________________, ____________________, and ____________________.

   d. Energy can be applied to ____________________ to change its shape or cause it to move.

   e. The action of energy upon matter is called ____________________ —the movement or changing of matter, including changing its state of matter.

   f. The amount of work that a quantity of energy can do is called ____________________.

   g. The amount of force that is applied within a given period of time is called ____________________.

   h. Force, and therefore power, can be moved from its source to produce work at a location distant from the source through a process called ____________________.

2. Define the types of power-transmission systems. Write your answers on the blanks provided beside each of the terms below and on the next page.

   a. Mechanical ____

   ____

   b. Hydraulic ____

   ____

c. Pneumatic ______________________________

____

d. Electrical ______________________________

____

e. Magnetic ______________________________

____

3. Define the term *drive system*. Write your answer on the blanks provided beside the term below.

Drive system ______________________________

____

____

4. State the functions of the types of drive systems used in power product equipment. Write your answers on the blanks provided beside each of the terms below.

a. Drive train ______________________________

____

____

b. Equipment drive ______________________________

____

____

5. State the function of a clutch in a drive system. Write your answer on the blanks provided below.

____

____

____

6. List the types of drive trains used in power product equipment. Write your answers on the blanks provided below.

a. ______________________________

b. ______________________________

c. ______________________________

Written Test

7. List the characteristics used to classify drive trains. Write your answers on the blanks provided below.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

8. Distinguish between the definitions of the types of output configurations used in drive trains. Write a "T" on the blank provided before the definition of a transmission, and an "A" on the blank before the definition of a transaxle.

   ______ a. Output configuration that transfers engine power directly to the drive wheels

   ______ b. Output configuration that transfers engine power to the final drive at one or more speeds and often in forward and reverse directions

9. List the types of equipment drives used in power product equipment. Write your answers on the blanks provided below.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

10. State the functions of the major components of an equipment drive. Write your answers on the blanks provided beside each of the terms below.

    a. Power source ______________________________

    ____

    b. Actuator ______________________________

    ____

    c. Power output ______________________________

    ____

    d. Linkage ______________________________

    ____

Written Test

11. Match types of clutch systems to their correct descriptions. Write the numbers on the blanks provided.

_______ a. The clutch uses belts, chains, gears, or friction surfaces to provide connections between the power source and the drive output.

_______ b. A liquid is used to apply or remove the pressure necessary to hold the power source and drive-output components in contact.

_______ c. Changes in air pressure are used to apply or remove the pressure necessary to hold the power source and drive-output components in contact.

_______ d. The clutch engages the drive system by magnetically attaching to a portion of the drive mechanism when electrical power energizes a magnetic portion of the clutch; the clutch disengages the drive system when the electrical power is removed and the clutch is no longer magnetized.

1. Electromagnetic
2. Hydraulic
3. Mechanical
4. Pneumatic

12. State the functions of the major components of a clutch system. Write your answers on the blanks provided beside each of the terms below.

a. Actuator ____

____

b. Power source ____

____

c. Clutch interface ____

____

d. Clutch output ____

____

e. Return mechanism ____

____

13. List devices used to actuate clutches. Write your answers on the blanks provided below.

a. ____
b. ____
c. ____
d. ____

Permission to duplicate this test is granted.

Principles of Power Transmission
Unit 1

Unit Evaluation Form

Student name ______________________________ Unit rating ______________

Assignment-sheet rating

Assignment Sheet 1—Determine Power-Transmission Characteristics of Power Product Equipment Rating ______

Comments: ____

____

Written-test scores

Pretest ________ Posttest ________ Other ________

Comments: ____

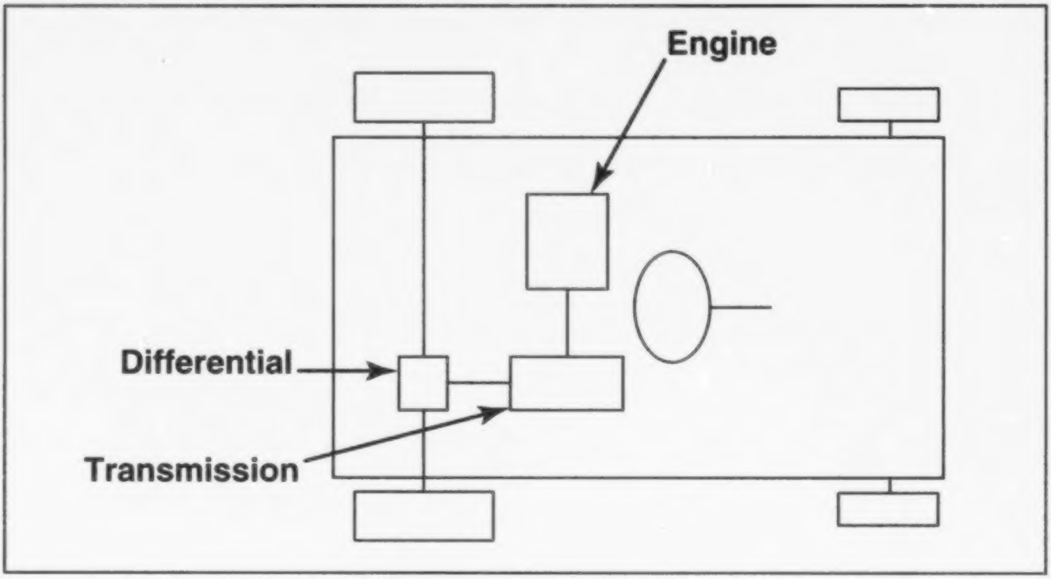
____

Teacher signature ______________________________ Date ______________

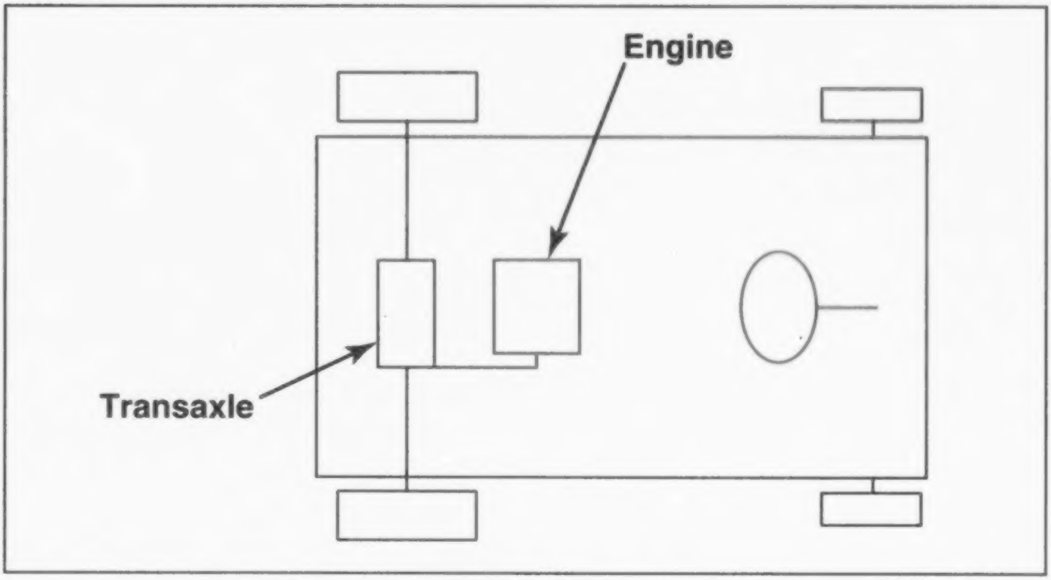
Student signature ______________________________ Date ______________

Permission to duplicate this form is granted.

Types of Output Configurations Used in Drive Trains


Engine
Differential
Transmission

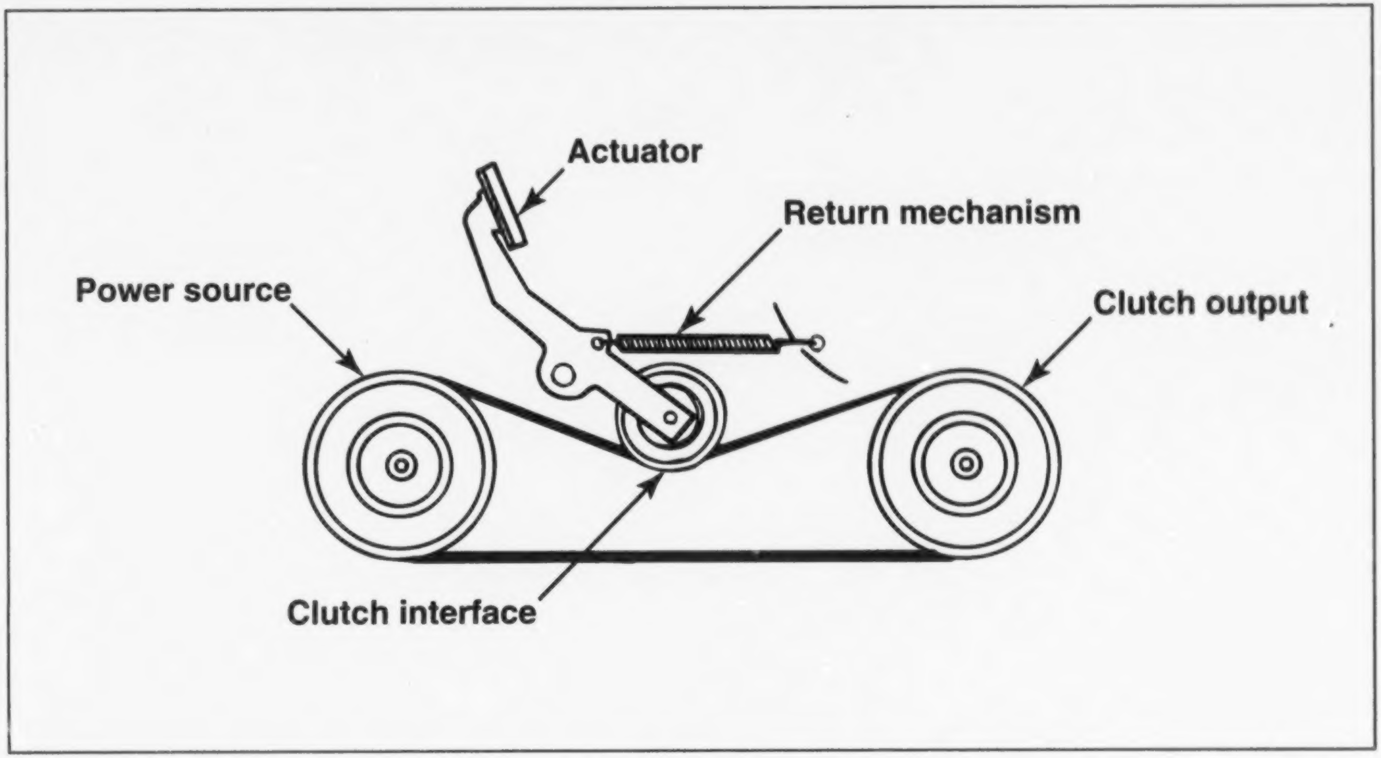
Transmission


Engine
Transaxle

Transaxle

TM 1

Major Components of a Clutch System


Actuator
Return mechanism
Power source
Clutch output
Clutch interface

Mechanical Drive Systems
Unit 2

Suggested Activities

Instructional plan

Preparation

- Review the unit in the student edition and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Display equipment and illustrations that provide examples of mechanical drive systems.
- Make transparencies from the transparency masters included in the teacher pages of this unit.
- Select teacher components (written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution.
- Review the job sheets in the student edition and locate the worksheet masters included in the teacher pages of this unit. Copy and prepare extra worksheets for distribution to your students.

Delivery and application

Unit introduction

The skill areas appearing in bold-face type in the unit introduction and teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want.* These have been adapted by MAVCC.

- Provide the students with the student edition of this unit. You may choose to begin by discussing the objective sheet. Review the unit and specific objectives with the students. Discuss how meeting the unit objective will improve their employability or will increase their value as an employee. Explain how the specific objectives support the unit objective. **(Listening; oral communication; adapting to the organization's traditional modes of operation; emphasizing personal and career development)**

Suggested Activities

Teaching suggestions

Objective 1 List the types of belts used in mechanical drive systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 1, "Types of Belts Used in Mechanical Drive Systems," to aid the discussion. **(Reading/listening for content)**

- Use actual equipment to provide examples of V-, flat, and cogged belts. Discuss both the design and construction of belts. Show the students cross-sections of belts to demonstrate strength cords, the tension section, the compression section, and other features. Compare standard and heavy-duty constructions. Have the students use service manuals and parts catalogs to identify the belts used on various pieces of equipment and the costs of these items. **(Listening; reading; seeing things in the mind's eye; acquiring, interpreting, and processing information; system interrelationships)**

Objective 2 List the types of chains used in mechanical drive systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 2, "Types of Chains Used in Mechanical Drive Systems," to aid the discussion. **(Reading/listening for content)**

- Provide examples of O-ring and double-roller chains. Discuss advantages and disadvantages of each type of chain as related to specific applications. Note similarities and differences as compared to the belts discussed in the previous objective. **(Listening; reading; seeing things in the mind's eye; acquiring, interpreting, and processing information; system interrelationships)**

- Discuss the design and construction of drive chains. Have the students use service manuals and parts catalogs to identify the chains used on various pieces of equipment and the costs of these items. **(Listening; reading; acquiring, interpreting, and processing information; system interrelationships)**

Objective 3 Label the types of gears used in mechanical drive systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 3, "Types of Gears Used in Mechanical Drive Systems," to aid the discussion. **(Reading/listening for content)**

- Provide actual examples of straight, helical, bevel, and worm gears. Discuss advantages and disadvantages of each type as related to specific applications. Note similarities and differences as compared to the belts and chains discussed in the previous objectives. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

- Discuss the design and construction of drive gears. Have the students use service manuals and parts catalogs to identify the gears used on various pieces of equipment and the costs of these items. **(Listening; reading; acquiring, interpreting, and processing information; system interrelationships)**

Student Supplement 1 Mechanical Gears, Belts, and Chains.
Student Supplement 2 Bearings and Bushings

- Read and discuss with students the information presented in these supplements. **(Reading/listening for content)**

Objective 4 Describe the types of shafts used in mechanical drive systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparencies 4 through 6 to aid the discussion. **(Reading/listening for content)**

- Provide examples of solid, jointed, and telescoping shafts. Discuss advantages and disadvantages of each type of shaft as related to specific applications. Note similarities and differences as compared to the belts, chains, and gears discussed in the previous objectives. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

- Discuss the design and construction of drive shafts. Have the students use service manuals and parts catalogs to identify the shafts used on various pieces of equipment and the costs of these items. Discuss shaft connection designs, and the use of U-joints and other types of connections. Have the students gather parts information for these items. **(Listening; reading; acquiring, interpreting, and processing information; system interrelationships)**

Objective 5 Label the types of mechanical drive trains.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparencies 7 and 8 to aid the discussion. **(Reading/listening for content)**

- Provide actual examples of belt and gear drive trains, and give an overview of how they are similar and different. Have the students identify mechanical drive trains on equipment in your facility. Relate the operation of mechanical drive trains to the remaining specific objectives of this unit. **(Listening; reading; seeing things in the mind's eye; system interrelationships)**

Objective 6 State the functions of the major components of belt drive trains. **Objective 7** Complete statements about the principles of operation of belt drive trains.

- Read and discuss with students the information presented in these sections of the information sheet. Use Transparency 7, "Types of Mechanical Drive Trains: Typical Belt Drive Train," to aid your discussion. **(Reading/listening for content)**

Suggested Activities

- Compare the operation of various types of belt drive trains. Explain the purpose and function of the major components of a particular system and then relate those functions to corresponding components in other designs. **(Listening; seeing things in the mind's eye; system interrelationships)**

- Display examples of the various belt arrangements, such as open, turned, crossed, serpentine, mule, etc. Have the students identify the corresponding components in the different configurations. **(Listening; seeing things in the mind's eye; system interrelationships)**

- Demonstrate the operation of a variety of belt drive trains on various types of equipment. Point out the routing of the belts and the path of power transfer. Discuss factors such as tension and variable-speed pulleys, slippage, pulley wear and alignment, etc. **(Listening; seeing things in the mind's eye; system interrelationships)**

Objective 8 State the functions of the major components of gear drive trains. **Objective 9** Complete statements about the principles of operation of gear drive trains.

- Read and discuss with students the information presented in these sections of the information sheet. Use Transparency 8, "Types of Mechanical Drive Trains: Typical Gear Drive Train," to aid your discussion. **(Reading/listening for content)**

- Provide actual examples of each type of gear drive train. Discuss advantages and disadvantages of each type as related to specific applications. Note similarities and differences as compared to the belt drive trains discussed in the previous objectives. **(Listening; seeing things in the mind's eye; acquiring, interpreting, and processing information; system interrelationships)**

- Provide examples of various types of gears. Discuss the design and construction of drive gears. Have the students use service manuals and parts catalogs to identify the gears used on various pieces of equipment and the costs of these items. **(Listening; reading; acquiring, interpreting, and processing information; system interrelationships)**

Assignment Sheet 1 Determine mechanical drive-train service specifications and parts requirements.

- Have students locate Assignment Sheet 1. Read the introduction and directions to the assignment. **(Reading/listening for content; seeing things in the mind's eye; reasoning)**

- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Listening; reading; writing; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

Suggested Activities

- Answer any student questions and have students complete Assignment Sheet 1.

Job Sheet 1 Perform routine maintenance on mechanical drive trains.

- Have students locate Job Sheet 1 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on mechanical drive-train systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the mechanical drive-train system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 1.

Job Sheet 2 Repair mechanical drive trains.

- Have students locate Job Sheet 2 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing mechanical drive-train systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the mechanical drive-train system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 2.

Objective 10 Label the types of mechanical equipment drives. **Objective 11** Complete statements about the principles of operation of mechanical-PTO equipment drives. **Objective 12** Complete statements about the principles of operation of ground-drive equipment drives.

- Read and discuss with students the information presented in these sections of the information sheet. Use Transparency 9, "Types of Mechanical Equipment Drives," to aid the discussion. **(Reading/listening for content)**

- Use actual equipment to describe the operation of mechanical-PTO and ground-drive equipment drives. Modify the items listed in the information sheet as they apply to specific types of systems. Discuss how the operation of each type of system makes it suitable or unsuitable for specific applications. For example, a ground drive may be efficient and durable, but such a system is likely to be too complex, heavy, and expensive if on a small riding lawn mower. **(Listening; reading; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Suggested Activities

Objective 13 List typical service procedures required for belt drive systems. **Objective 14** List typical service procedures required for chain drive systems. **Objective 15** List typical service procedures required for gear drive systems. **Objective 16** List typical service procedures required for shaft drive systems.

- Read and discuss with students the information presented in these sections of the information sheet. **(Reading/listening for content)**

- Provide equipment, tools, and service manuals to support your discussion of service procedures. Display wall charts related to the service procedures. Point out comparable procedures for different types of mechanical drive systems. Emphasize those procedures that will be covered in your presentation of the job sheets and perform relevant demonstrations. Tailor the procedures to the type of equipment and tools available in your facility. **(Listening; reading; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

- Relate the procedures to other aspects of your course. For example, discuss how tools and materials are issued in your facility and the students' responsibilities in caring for tools. Demonstrate the use of specification resources, including manuals, microfiche, computer data bases, and other resources. Explain job-ticket procedures and work assignments as applicable. Tailor these discussions to your students' needs based on their previous experiences in your facility and their training backgrounds. **(Listening; reading; writing; reasoning; acquiring, interpreting, and processing information; science; system interrelationships)**

  Note: For information and student activities pertaining to the use of resources, tool issue, safety, and related topics, see MAVCC's introductory volume in this series, *Theory and Principles of Engine Operation.*

Assignment Sheet 2 Determine mechanical equipment-drive service specifications and parts requirements.

- Have students locate Assignment Sheet 2. Read the introduction and directions to the assignment. **(Reading/listening for content; seeing things in the mind's eye; reasoning)**

- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Listening; reading; writing; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

- Answer any student questions and have students complete Assignment Sheet 2.

Suggested Activities

Job Sheet 3 Perform routine maintenance on mechanical equipment drives.

- Have students locate Job Sheet 3 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on mechanical equipment-drive systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the mechanical equipment-drive system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 3.

Job Sheet 4 Repair mechanical equipment drives.

- Have students locate Job Sheet 4 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing mechanical equipment-drive systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the mechanical equipment-drive system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 4.

Objective 17 Label types of mechanical clutch systems. **Objective 18** Describe the principles of operation of belt clutch systems. **Objective 19** Describe the principles of operation of jaw clutch systems. **Objective 20** Describe the principles of operation of friction clutch systems. **Objective 21** Describe the principles of operation of centrifugal clutch systems. **Objective 22** Describe the principles of operation of multi-disc clutch systems.

- Read and discuss with students the information presented in these sections of the information sheet. Use Transparencies 10 through 14 to aid the discussion. **(Reading/listening for content)**

- Supplement the discussion with examples of actual equipment using the various types of mechanical clutch systems. Highlight the major components and operation of each type of system. Discuss the advantages and disadvantages of each type of system and typical applications of each. **(Listening; reading; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 23 State safety rules for working with mechanical clutch systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

Suggested Activities

- Relate the operation of mechanical clutch systems to dangers present in the operation or maintenance of such systems. Discuss belt and spring tensions and the dangers associated with these devices. Invite persons who have suffered disabling accidents or have treated those who have experienced disabling accidents related to clutch and drive systems to discuss the dangers of such systems with the class. Review first-aid procedures and the policies of your facility in the event of an accident. Review locations of safety equipment. **(Listening; reading; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

- If applicable to your course, discuss the use of asbestos in some friction-plate clutch systems. Review the dangers of asbestos. Invite someone from a health agency or environmental-quality agency to discuss asbestos with your class. **(Listening; reading; seeing things in the mind's eye; interpreting and processing information)**

Objective 24 List typical service procedures required for mechanical clutch systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Display wall charts related to the service procedures. Point out comparable procedures for different types of clutch systems. Emphasize those procedures that will be covered in your presentation of the job sheets and perform relevant demonstrations. Tailor the procedures to the type of equipment and tools available in your facility. **(Listening; reading; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

Assignment Sheet 3 Determine mechanical clutch-system service specifications and parts requirements.

- Have students locate Assignment Sheet 3. Read the introduction and directions to the assignment. **(Reading/listening for content; seeing things in the mind's eye; reasoning)**

- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Listening; reading; writing; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

- Answer any student questions and have students complete Assignment Sheet 3.

Job Sheet 5 Perform routine maintenance on mechanical clutch systems.

- Have students locate Job Sheet 5 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on mechanical clutch systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

Suggested Activities

- Provide students with power product equipment that requires routine maintenance of the mechanical clutch system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 5.

Job Sheet 6 Repair mechanical clutch systems.

- Have students locate Job Sheet 6 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing mechanical clutch systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment that requires repair of the mechanical clutch system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 6.

Evaluation

- Evaluate the assignment sheets. See the evaluation criteria listed at the top of each assignment sheet as well as the teacher page "Answers to Assignment Sheets."
- Evaluate the job sheets.

When the student is ready to perform a specific task, obtain a copy of the worksheet associated with each job sheet. Worksheets may be found in the student edition and in the teacher pages following the transparency masters. Then, observe the student performing the procedure.

After the student has completed the procedure, rate the student using the criteria provided on the worksheet. If the student's performance is unacceptable, have the student review the materials and perform the procedure again for evaluation.

Two sample performance evaluation keys are provided on the next page. Many other keys are available. Select one evaluation key (grading scale) that best fits your program needs.

Suggested Activities

Performance Evaluation Keys

Sample A

4 — Skilled—Can perform job with no additional training.
3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
1 — Unskilled—Is familiar with process, but is unable to perform job.

Sample B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

- Give the written test. See the teacher page "Written Test."
- Evaluate the written test. See the teacher page "Answers to Written Test."
- Compile written-test, assignment-sheet, and job-sheet scores. See the teacher page "Unit Evaluation Form."
- Reteach and retest as required.

Suggested resources

Resources used in developing this unit

Print media

- Graf, Rudolf F., and George J. Whalen. *VNR Illustrated Guide to Power Tools.* New York: Van Nostrand Reinhold Company, 1978.
- Hawker, M. F. J. and J. F. Keenlyside. *Horticultural Machinery,* 3rd ed. Essex, England: Longman Group Limited, 1985.
- Jorgensen, Eric, editor. *Kawasaki 250-750cc Triples,* 5th ed. Arleta, California: Clymer Publications, 1979.
- *MTD Yard-Man Technical Service Handbook.* Cleveland, Ohio: MTD Products, Inc., 1996.
- *Outdoor Power Equipment Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1985.
- *Power Tools and Equipment.* Alexandria, Virginia: Time-Life Books, Inc., 1989.

- *Power Trains: Compact Equipment.* Moline, Illinois: Deere and Company, 1991.
- *Riding Lawn Mower Service Manual,* 4th ed. Overland Park, Kansas: Intertec Publishing Corporation, 1993.
- *Small Tractor Service Manual.* Overland Park, Kansas: Intertec Publishing Corporation, 1984.
- Wright, Ron. *Harley-Davidson Sportsters,* 7th ed. Arleta, California: Clymer Publications, 1986.
- *Yard and Garden Tractor Service Manual,* 1st ed. Overland Park, Kansas: Intertec Publishing Corporation, 1992.

Suggested supplemental resources

Print media

- *Outdoor Power Equipment* magazine. Adams/Green Industry Publishing, 68860 Perez Road, Suite J, Cathedral City, California 92234. Web site: http://www.outdoorpowerequipment.com
- *Power Equipment Trade* magazine. Hatton-Brown Publishers, Inc., P. O. Box 2268, Montgomery, Alabama 36102.
- *Technical Handbook.* Describes the makes and types of equipment produced by MTD—one of the nation's largest manufacturers. The book covers service for most equipment systems and various types of equipment. Both light- and heavy-duty equipment types are included. Available from MTD Products, Inc. Call 1-800-422-3381.
- Service manuals for systems covered in this unit.
- Parts catalogs for systems covered in this unit. Available from equipment manufacturers.

Nonprint media

- *Antifriction Bearings.* L&K International Videotraining, P.O. Box 940 Station U, Toronto, Ontario M8Z 5P9, Canada, (416) 252-6407.
- *Bearings.* NUS Training Corporation, 910 Clopper Road, Gaithersburg, Maryland 20878-1399, (800) 848-1717.
- *Chain and Chain Drive.* Lucerne Media, 37 Ground Pine Road, Morris Plains, New Jersey 07950, (800) 341-2293.
- *Equipment Drive Components.* NUS Training Corporation, 910 Clopper Road, Gaithersburg, Maryland 20878-1399, (800) 848-1717.
- *Gears.* NUS Training Corporation, 910 Clopper Road, Gaithersburg, Maryland 20878-1399, (800) 848-1717.
- *The Physical World of a Machine.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (615) 624-2628.

Suggested Activities

- *Roller Chain.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (615) 624-2628.
- *V-Belt Drive Selection.* MAJEC, 1125 E Street, Charles Road, Lombard, Illinois 60148, (708) 530-0744.
- *V-Belt Installation and Maintenance.* MAJEC, 1125 E Street, Charles Road, Lombard, Illinois 60148, (708) 530-0744.
- *V-Belt: Proper Care.* Marshall Maintenance Productions, 529 S. Clinton Avenue, Trenton, New Jersey 08611, (800) 257-0430.
- *V-Belts.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (615) 624-2628.
- *V-Belts and Sheaves.* MAJEC, 1125 E Street, Charles Road, Lombard, Illinois 60148, (708) 530-0744.
- *V-Belts and V-Belt Drives.* Lucerne Media, 37 Ground Pine Road, Morris Plains, New Jersey 07950, (800) 341-2293.

Mechanical Drive Systems
Unit 2

Answers to Assignment Sheets

Assignment Sheet 1—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1. a. RTV silicone liquid gasket
   b. As determined by references available in the facility
   c. SAE 80W90
   d. 4
   e. 8 to 10 ft-lbs (11 to 13 N•m)

2. a. ⅛ to ¼ inch (3.2 to 6.4 mm) on the side opposite the idler
   b. SAE 30 oil

3. a. ⅛ to 3⁄16 inch
   ⅛ inch
   ⅛ inch
   b. Engaged

4. a. Higher
   b. Center
   c. Bent or loose spindle or carrier frame

Assignment Sheet 2—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1. a. 2
   b. 7
   c. 4
   d. ½ x 34 inches
   e. ½ x 32 inches

2. a. #50
   b. #35

3. a. Electric
   b. ⅛ inch (3.2 mm)
   c. 0.015 to 0.020 inch (0.4 to 0.5 mm)

4. a. Keyed design—681-0002
   Tapered design—681-0030
   b. Steel blade—781-0490
   Chrome blade—742-0544
   c. 550 to 650 in-lbs

Assignment Sheet 3—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1. Item 6 is a flat idler, while Item 7 is a V-belt idler.

2. a. Yes
   b. 22 ft-lbs (30 N•m)
   c. Replace the springs as a set.

3. a. 78 in-lbs (0.9 kg-m)
   b. 0.3 mm
   c. Apply engine oil
   d. Yes
   e. 61 ft-lbs (8.5 kg-m)

4. a. Rod and chain
   b. Roller pins
   c. 0.132 inch (1 mm)
   d. ½ inch (13 mm)
   e. 15

Mechanical Drive Systems
Unit 2

Answers to Written Test

1. Answers may appear in any order.

   - V-belt
   - Flat belt
   - Cogged belt

2. Answers may appear in any order.

   - Double roller
   - O-ring

3. a. Worm gear
   b. Bevel gear
   c. Straight gear
   d. Helical gear

4. a. Shaft that consists of a single piece
   b. Shaft that consists of two or more pieces, and each piece is joined to the next piece with a universal joint
   c. Shaft that consists of two pieces, one of which slides into the other

5. a. Belt drive train
   b. Gear drive train

6. a. Provides rotary power from the engine
   b. Transmits power from the engine-output pulley
   c. Increases or releases tension on the drive belt
   d. Provides power input to the final drive

7. a. engine-output pulley
   b. Idler pulley; engine-output pulley; transmission pulleys

8. a. Brings power from the engine into the transmission
   b. Transmits power to the countershaft and changes the direction of rotational force
   c. Holds the drive gears
   d. Transmit power to the speed gears
   e. Positions the speed gears in relation to the drive gears to vary the output-gear ratio or to vary the direction of travel
   f. Transfer power to the output shaft
   g. Drives the output shaft in the opposite direction of the speed gears
   h. Meshes with the reverse chain to change the direction of rotation of the output shaft
   i. Provides power to the final drive

Answers to Written Test

9. a. input shaft
   b. input shaft; drive gears
   c. shift-rod and fork
   d. output shaft; differential
   e. differential
   f. differential; drive axles

10. a. Mechanical PTO
    b. Ground drive

11. a. engine-output shaft
    b. belt; chain; gear

12. a. engine
    b. gears; belts; mechanical means

13. Answers may appear in any order.

- Adjust belt tension
- Replace belt
- Align pulley
- Replace pulley
- Lubricate spindle and pulley bearings
- Adjust actuating mechanism

14. Answers may appear in any order.

- Adjust chain tension
- Replace chain links
- Replace chain
- Align chain
- Replace sprockets
- Lubricate spindles and shafts
- Adjust actuating mechanism

15. Answers may appear in any order.

- Adjust gear alignment
- Replace gears
- Replace gears shafts
- Lubricate gears and shafts
- Adjust engagement mechanism

Answers to Written Test

16. Answers may appear in any order.

    - Adjust shaft length
    - Replace shaft
    - Lubricate shafts and joints
    - Replace joints
    - Adjust actuating mechanism

17.
    a. Centrifugal
    b. Belt
    c. Multi-disc
    d. Friction
    e. Jaw

18.
    a. The engine pulley is mounted on the end of the engine crankshaft and turns whenever the engine is running.

    b. A belt is routed over the engine pulley, and the other end of the belt is routed over a drive pulley mounted on the end of the transmission or equipment drive.

    c. When the operator releases the clutch actuator, the tension applied by the engaging spring to the idler pulley is strong enough to deflect the belt so that the rotation of the engine pulley moves the belt and causes the drive pulley to turn.

    d. When the operator actuates the clutch, the tension of the engaging spring is overcome, causing the idler pulley to lessen the tension on the belt. With the tension on the belt released, the rotary force of the engine is no longer transferred to the drive pulley.

19.
    a. The engine pulley, sprocket, or gear is mounted on the end of the engine crankshaft and turns whenever the engine is running.

    b. A belt, chain, or gear transfers power from the engine member to a corresponding drive member that rotates the drive gear.

    c. When the operator releases the clutch actuator, pressure from a lever slides the jaw clutch along a shaft and holds it in contact with the drive gear. In this position, the jaw clutch mates with a gear, collar, or other structure on the shaft of the drive train or equipment drive so that the rotation of the drive gear is transferred to the jaw clutch and then to the drive shaft.

    d. When the operator actuates the clutch, the lever moves from the jaw clutch, removing the pressure that holds the jaw clutch engaged with the drive gear, thus breaking the linkage to the engine output.

Answers to Written Test

20. a. A friction surface is mounted to the end of the engine crankshaft and turns whenever the engine is running.

    b. A second friction surface is mounted to the drive shaft of the transmission or equipment drive.

    c. When the operator releases the clutch actuator, the pressure of the engaging spring is strong enough to hold the two friction surfaces in contact so that the rotation of the engine friction surface causes the drive shaft to turn.

    d. When the operator actuates the clutch, the pressure of the engaging spring is overcome, causing the friction surfaces to separate. With the friction surfaces separated, the rotary force of the engine is no longer transferred to the drive shaft.

21. a. The clutch shoes are mounted on the end of the engine crankshaft and turn whenever the engine is running.

    b. The rotation of the clutch-shoe assembly creates centrifugal force, which causes the shoes to spread outward against the tension of the springs.

    c. When the engine speed is fast enough, the shoes contact the drum and, through friction, cause it to turn. The drum is connected to a shaft, pulley, gear, or sprocket that transfers rotary motion to the drive line or equipment drive.

    d. When the engine slows, the tension of the springs overcomes centrifugal force and pulls the shoes away from the drum. With the shoes disengaged, the rotary force of the engine is no longer transferred to the drum.

22. a. A friction disc is mounted to the end of the engine crankshaft and turns whenever the engine is running.

    b. A second friction surface is mounted to the drive shaft of the transmission or equipment drive.

    c. When the operator releases the actuator, the pressure of the engaging spring is strong enough to hold the two friction surfaces in contact so that the rotation of the engine friction surface causes the drive shaft to turn.

    d. When the operator actuates the clutch, the pressure of the engaging spring is overcome, causing the friction surfaces to separate. With the friction surfaces separated, the rotary force of the engine is no longer transferred to the drive shaft.

23. a. Check to see whether clutch components contain asbestos, and if so, follow your facility's asbestos-handling procedures.

    b. Be careful when working with the clutch springs; they may become flying objects if they become disengaged or break.

    c. Never work on a clutch when the engine is operating.

Answers to Written Test

d. Check clutch components for cracked or frayed belts, cracked or delaminated friction surfaces, and any deterioration that may have occurred during operation.

e. Do not overtighten parts or apply excessive pressure to springs and belts.

f. Do not remove safety devices or make them inoperable.

g. Be careful not to become entangled in the moving parts of the clutch.

24. Answers may appear in any order.

- Replace belts
- Adjust belt tension
- Replace friction plates
- Replace and align pulleys
- Lubricate bearings
- Replace bearings
- Replace springs and other hardware

Mechanical Drive Systems
Unit 2

Written Test

Name ______________________________ Score ______________

1. List the types of belts used in mechanical drive systems. Write your answers on the blanks provided.

   a. ______________________________

   b. ______________________________

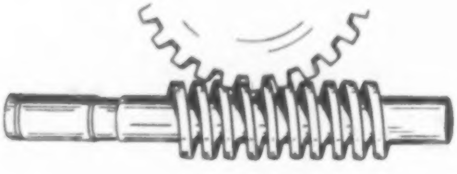
   c. ______________________________

2. List the types of chains used in mechanical drive systems. Write your answers on the blanks provided.

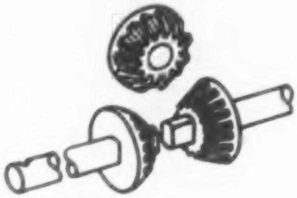
   a. ______________________________

   b. ______________________________

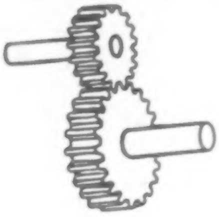
3. Label the types of gears used in mechanical drive systems. Write your answers on the blanks provided under each of the following illustrations.



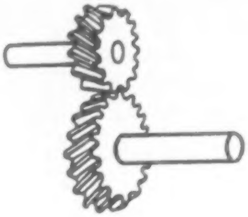
a. ______________________________



b. ______________________________



c. ______________________________



d. ______________________________

Written Test

4. Describe the types of shafts used in mechanical drive systems. Write your answers on the blanks provided beside each of the terms below.

    a. Solid shaft ______________________________

    ____

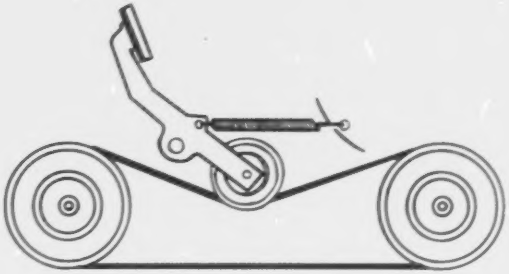
    b. Jointed shaft ______________________________

    ____

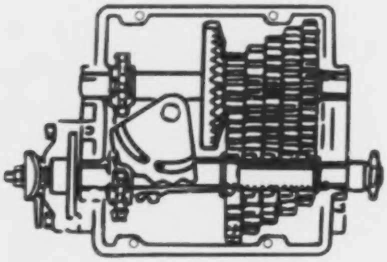
    c. Telescoping shaft ______________________________

    ____

5. Label the types of mechanical drive trains. Write your answers on the blanks provided under each of the following illustrations.



    a. ______________________________



    b. ______________________________

6. State the functions of the major components of belt drive trains. Write your answers on the blanks provided beside each of the terms below and on the next page.

    a. Engine-output pulley ______________________________

    ____

    b. Drive belt ______________________________

    ____

c. Idler pulley ____

____

d. Transmission pulley ____

____

7. Complete statements about the principles of operation of belt drive trains. Write the correct word(s) on the blanks provided in the statements below.

a. Rotary motion from the engine crankshaft is transferred to the ____________________, which is mounted on the crankshaft.

b. As the ____________________ applies tension to the drive belt, the ____________________ transmits power to the drive belt, which loops around one or more ____________________ or to the drive axle.

8. State the functions of the major components of gear drive trains. Write your answers on the blanks provided beside each of the terms below and on the next page.

a. Input shaft ____

____

____

b. Pinion gear ____

____

____

c. Countershaft ____

____

____

d. Drive gears ____

____

____

e. Shift-rod and fork assembly ____

____

____

f. Speed gears ______________________________

____

____

g. Reverse chain ______________________________

____

____

h. Reverse sprocket ______________________________

____

____

i. Output shaft ______________________________

____

____

9. Complete statements about the principles of operation of gear drive trains. Write the correct word(s) on the blanks provided in the statements below.

a. Rotary motion from the engine crankshaft is transferred to the transmission ______________________.

b. The ______________________ causes the countershaft to rotate, which turns the ______________________.

c. The ______________________ assembly is positioned by the operator to control the arrangement of gears so that a selected speed gear meshes with its drive gear.

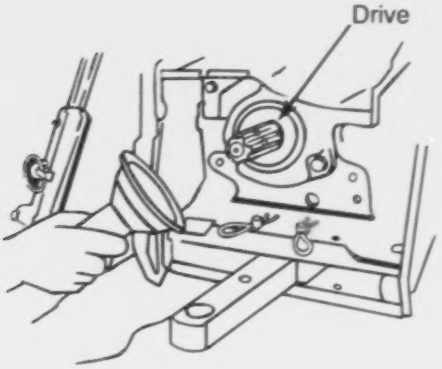
d. Power transferred through the transmission exists along the ______________________ with a linkage to the ______________________.

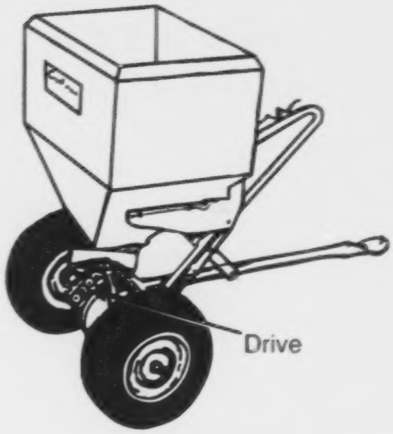
e. The power from the transmission drives the gears of the ______________________.

f. The ______________________ turns the ______________________, which turn the drive wheels to propel the vehicle.

Written Test

10. Label the types of mechanical equipment drives. Write your answers on the blanks provided under each of the following illustrations.





a. ______________________________ b. ______________________________

11. Complete statements about the principles of operation of mechanical-PTO equipment drives. Write the correct word(s) on the blanks provided in the statements below.

    a. The ________________________ turns a gear, pulley, or shaft.

    b. The gear, pulley, or shaft drives a ________________________, ________________________, or ________________________ to transfer rotary power to the equipment.

12. Complete statements about the principles of operation of ground-drive equipment drives. Write the correct word(s) on the blanks provided in the statements below.

    a. The turning of an axle produces rotary power in the axle without a link between that axle and the ________________________.

    b. The rotary power is transferred by ________________________, ________________________, or other ________________________ to power the equipment.

13. List typical service procedures required for belt drive systems. Write your answers on the blanks provided below and on the next page.

    a. ____

    b. ____

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

14. List typical service procedures required for chain drive systems. Write your answers on the blanks provided.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

15. List typical service procedures required for gear drive systems. Write your answers on the blanks provided.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

16. List typical service procedures required for shaft drive systems. Write your answers on the blanks provided.

a. ______________________________

b. ______________________________

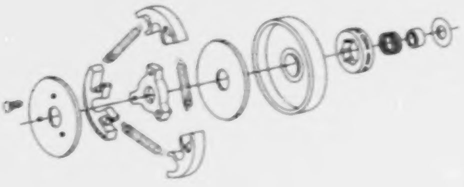
c. ______________________________

d. ______________________________

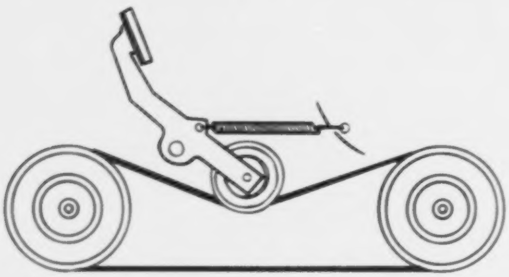
e. ______________________________

Written Test

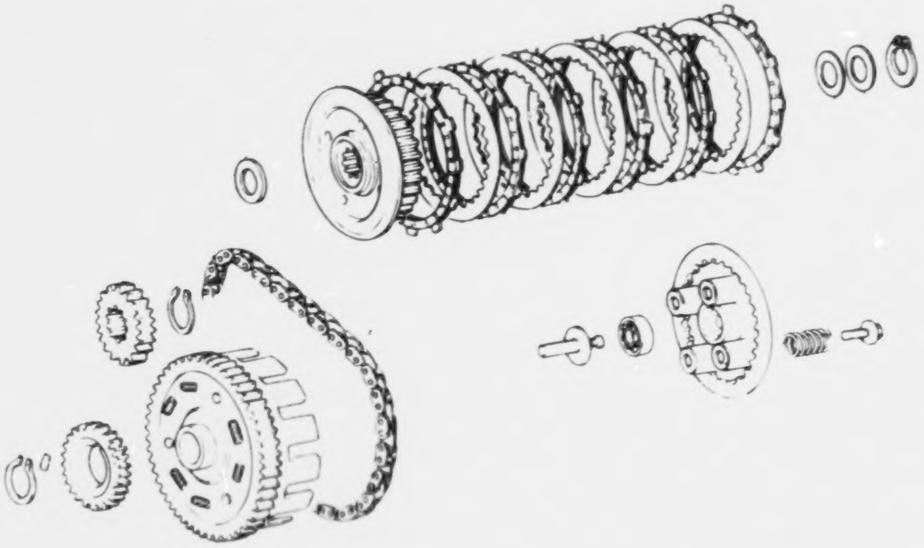
17. Label types of mechanical clutch systems. Write your answers on the blanks provided under each of the illustrations below and on the next page.



a. ____________________________________



b. ____________________________________



c. ____________________________________

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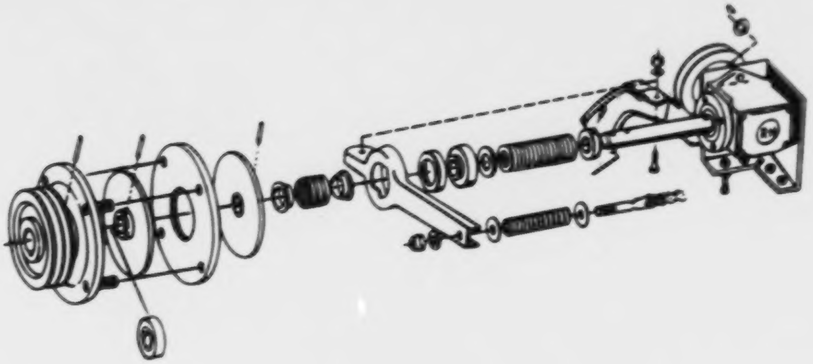
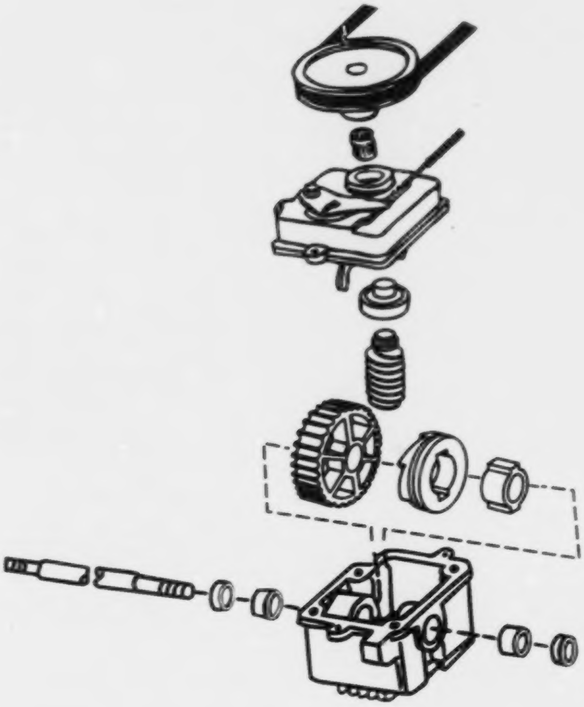


d. ____



e. ____

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Written Test

18. Describe the principles of operation of belt clutch systems. Write your answers on the blanks provided beside each of the terms below.

    a. Engine output ____

    ____

    ____

    ____

    b. Power transfer ____

    ____

    ____

    ____

    c. Clutch engaged ____

    ____

    ____

    ____

    d. Clutch disengaged ____

    ____

    ____

    ____

19. Describe the principles of operation of jaw clutch systems. Write your answers on the blanks provided beside each of the terms below and on the next page.

    a. Engine output ____

    ____

    ____

    ____

    b. Power transfer ____

    ____

    ____

    ____

c. Clutch engaged ____________________

d. Clutch disengaged ____________________

20. Describe the principles of operation of friction clutch systems. Write your answers on the blanks provided beside each of the terms below.

a. Engine output ____________________

b. Power transfer ____________________

c. Clutch engaged ____________________

d. Clutch disengaged ____________________

Written Test

21. Describe the principles of operation of centrifugal clutch systems. Write your answers on the blanks provided beside each of the terms below.

    a. Engine output ______________________________

    b. Power transfer ______________________________

    c. Clutch engaged ______________________________

    d. Clutch disengaged ______________________________

22. Describe the principles of operation of multi-disc clutch systems. Write your answers on the blanks provided beside each of the terms below and on the next page.

    a. Engine output ______________________________

    b. Power transfer ______________________________

c. Clutch engaged ____

____

____

____

d. Clutch disengaged ____

____

____

____

23. State safety rules for working with mechanical clutch systems. Write the complete safety rule on the blanks provided beside each of the terms below and on the next page.

a. Asbestos ____

____

____

b. Clutch springs ____

____

____

c. Operating engine ____

____

____

d. Clutch components ____

____

____

e. Overtighten parts ____

____

____

f. Safety devices ____________________

____

____

g. Moving parts ____________________

____

____

24. List typical service procedures required for mechanical clutch systems. Write your answers on the blanks provided.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

Permission to duplicate this test is granted.

Mechanical Drive Systems
Unit 2

Unit Evaluation Form

Student name ______________________________ Unit rating ____________

Assignment-sheet ratings

Assignment Sheet 1—Determine Mechanical Drive-Train Service Specifications and Parts Requirements Rating ______

Comments: ____

____

Assignment Sheet 2—Determine Mechanical Equipment-Drive Service Specifications and Parts Requirements Rating ______

Comments: ____

____

Assignment Sheet 3—Determine Mechanical Clutch-System Service Specifications and Parts Requirements Rating ______

Comments: ____

____

Job-sheet ratings

Job Sheet 1—Perform Routine Maintenance on Mechanical Drive Trains Rating ______

Comments: ____

____

Job Sheet 2—Repair Mechanical Drive Trains Rating ______

Comments: ____

____

Job Sheet 3—Perform Routine Maintenance on Mechanical Equipment Drives Rating ______

Comments: ____

____

Unit Evaluation Form

Job Sheet 4—Repair Mechanical Equipment Drives Rating ________

Comments: ____

____

Job Sheet 5—Perform Routine Maintenance on Mechanical Clutch Systems Rating ________

Comments: ____

____

Job Sheet 6—Repair Mechanical Clutch Systems Rating ________

Comments: ____

____

Written-test scores

Pretest ____________ Posttest ____________ Other ____________

Comments: ____

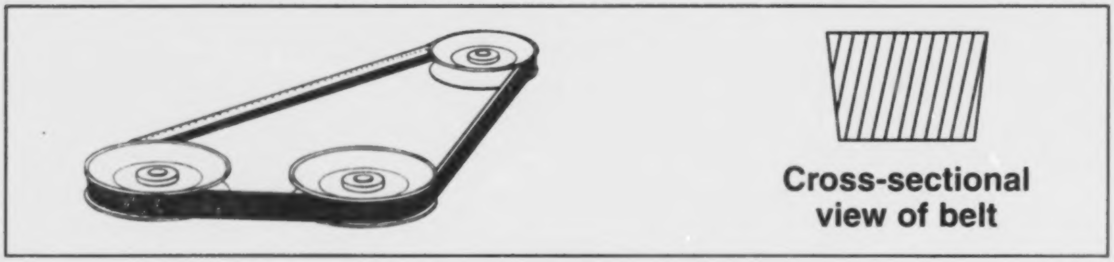
____

Teacher signature ______________________ Date ____________

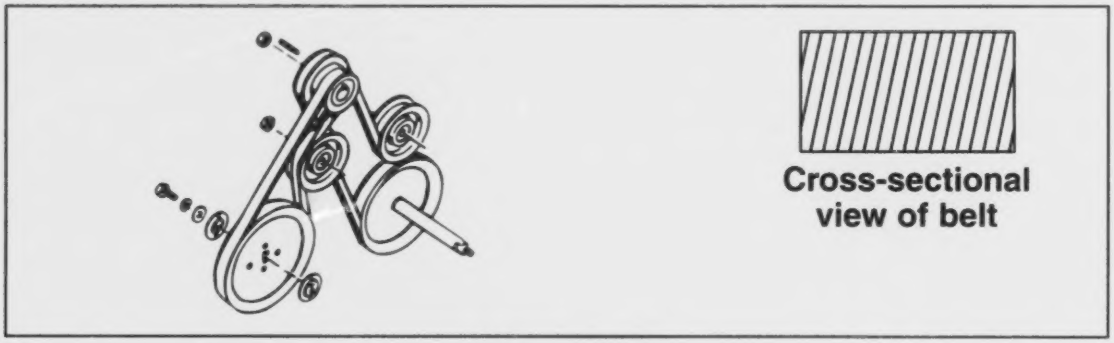
Student signature ______________________ Date ____________

Permission to duplicate this form is granted.

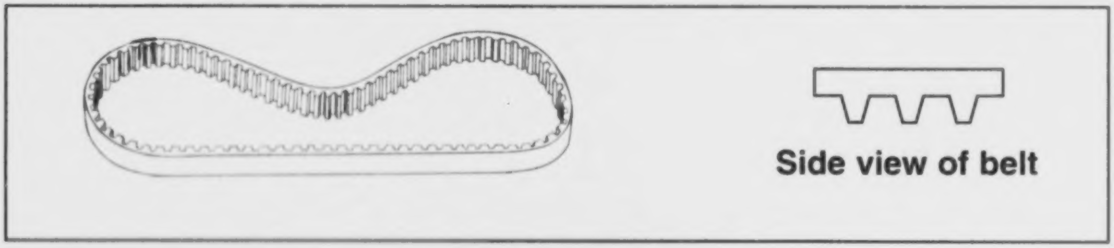
Types of Belts Used in Mechanical Drive Systems


Cross-sectional view of belt

V-Belt


Cross-sectional view of belt

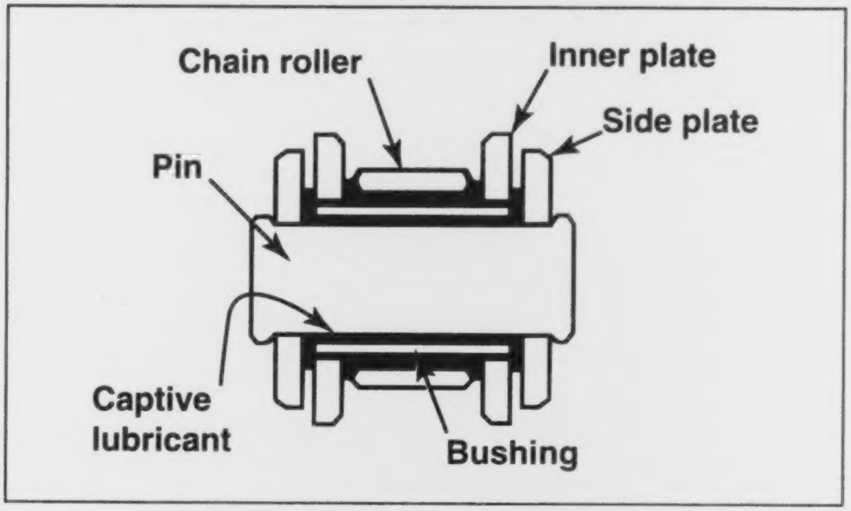
Flat Belt


Side view of belt

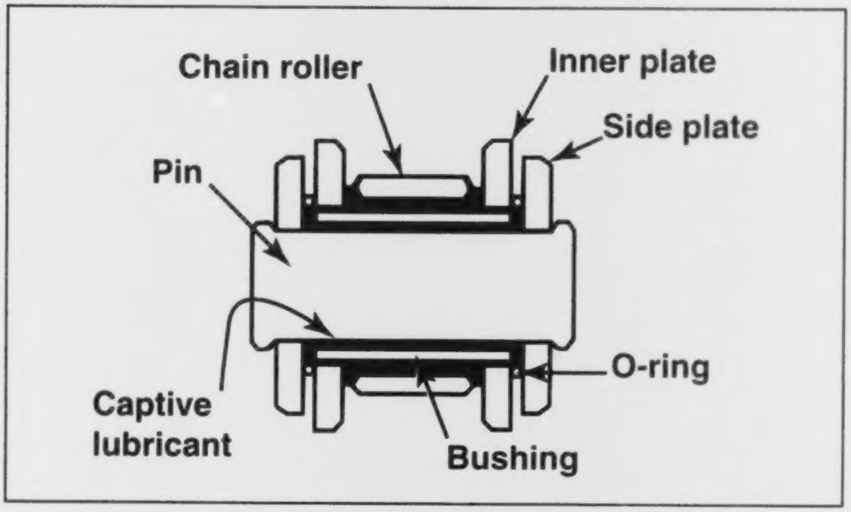
Cogged Belt

"Flat Belt" drawing reproduced by permission of Simplicity Manufacturing, Inc., Port Washington, Wisconsin.

Types of Chains Used in Mechanical Drive Systems


Chain roller
Inner plate
Side plate
Pin
Captive lubricant
Bushing

Double-Roller Chain


Chain roller
Inner plate
Side plate
Pin
O-ring
Captive lubricant
Bushing

O-Ring Chain

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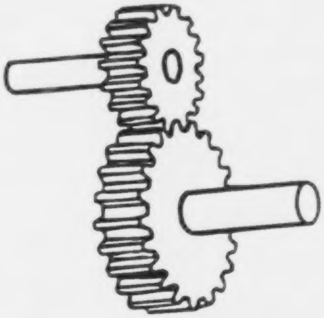
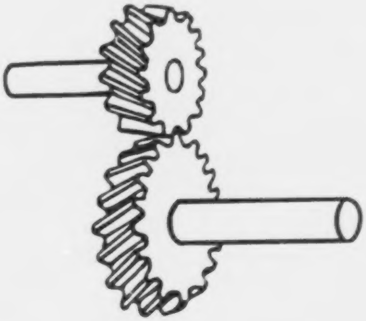
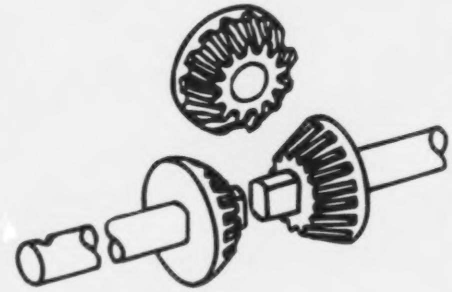
Types of Gears Used in Mechanical Drive Systems



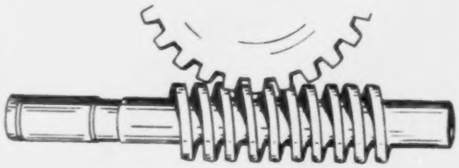
Straight gear



Helical gear



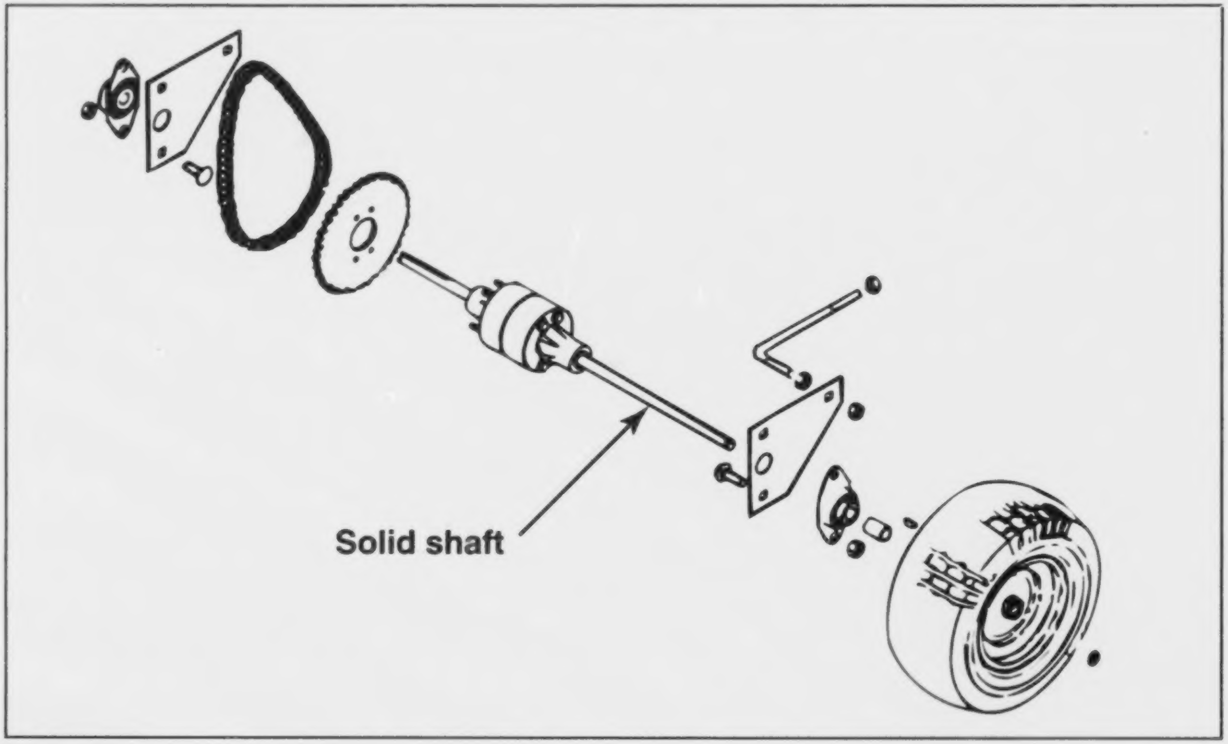
Bevel gear



Worm gear

Types of Shafts Used in Mechanical Drive Systems:

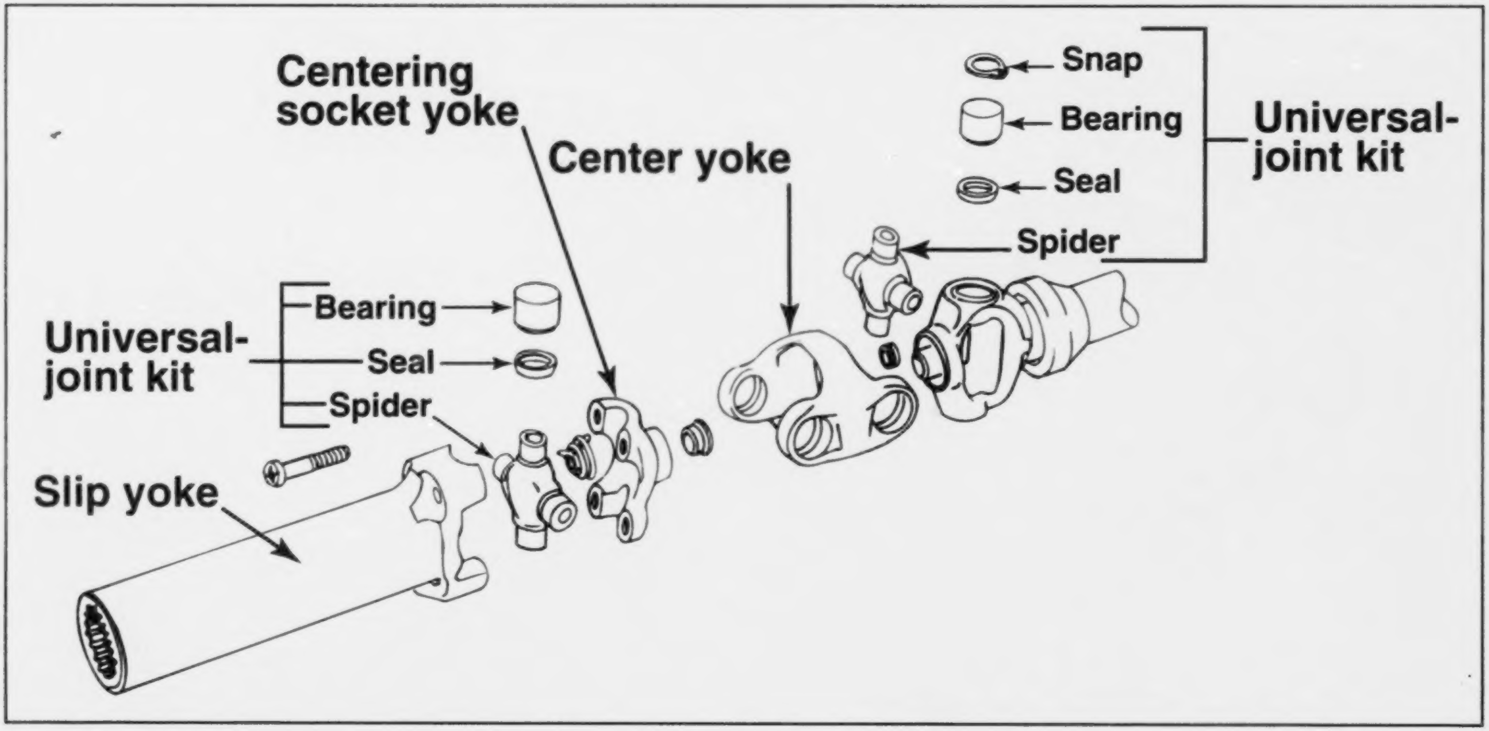
Solid Shaft



Drawing reproduced by permission of Gravely International, Brillion, Wisconsin.

Types of Shafts Used in Mechanical Drive Systems:

Jointed Shaft


Centering socket yoke
Center yoke
Snap
Bearing
Seal
Spider
Universal-joint kit
Bearing
Seal
Spider
Universal-joint kit
Slip yoke

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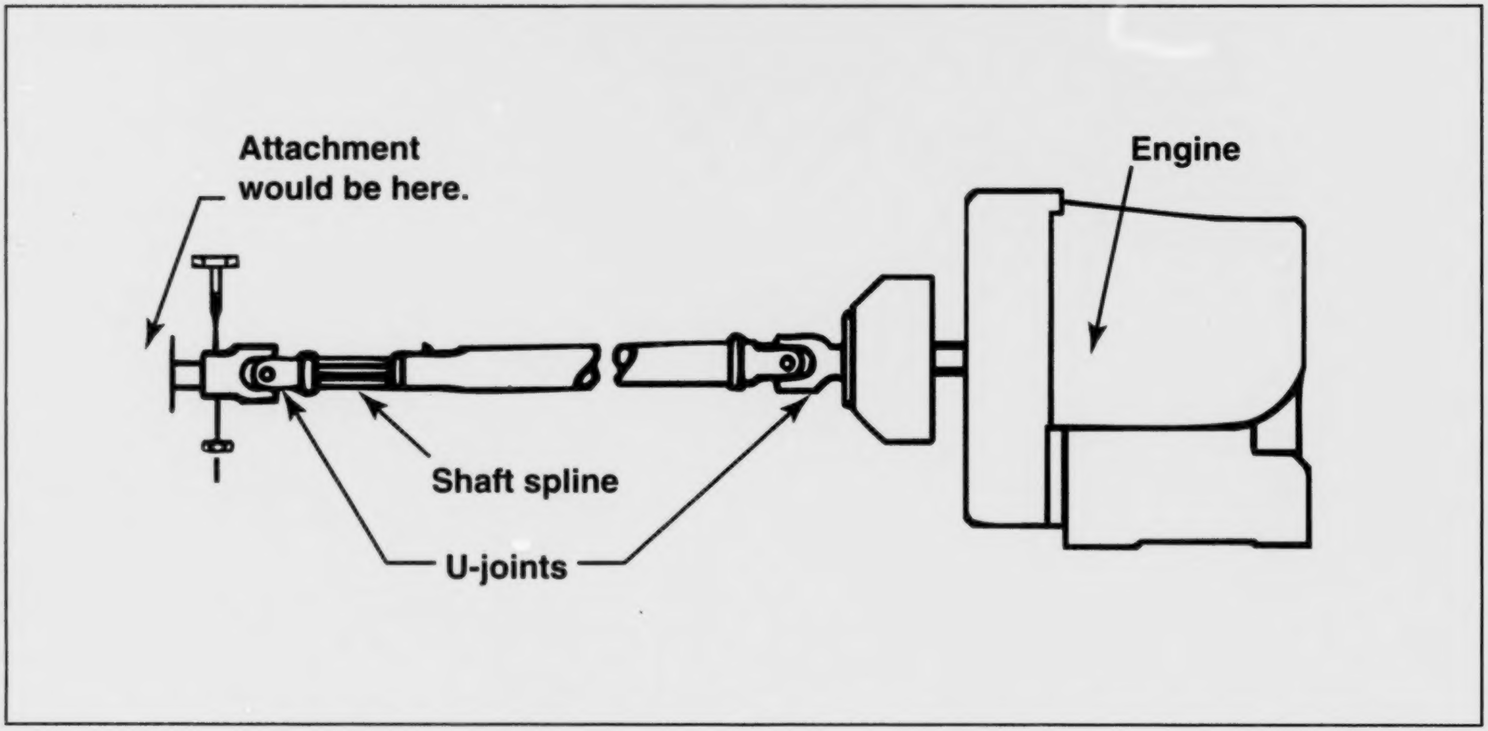
Types of Shafts Used in Mechanical Drive Systems:

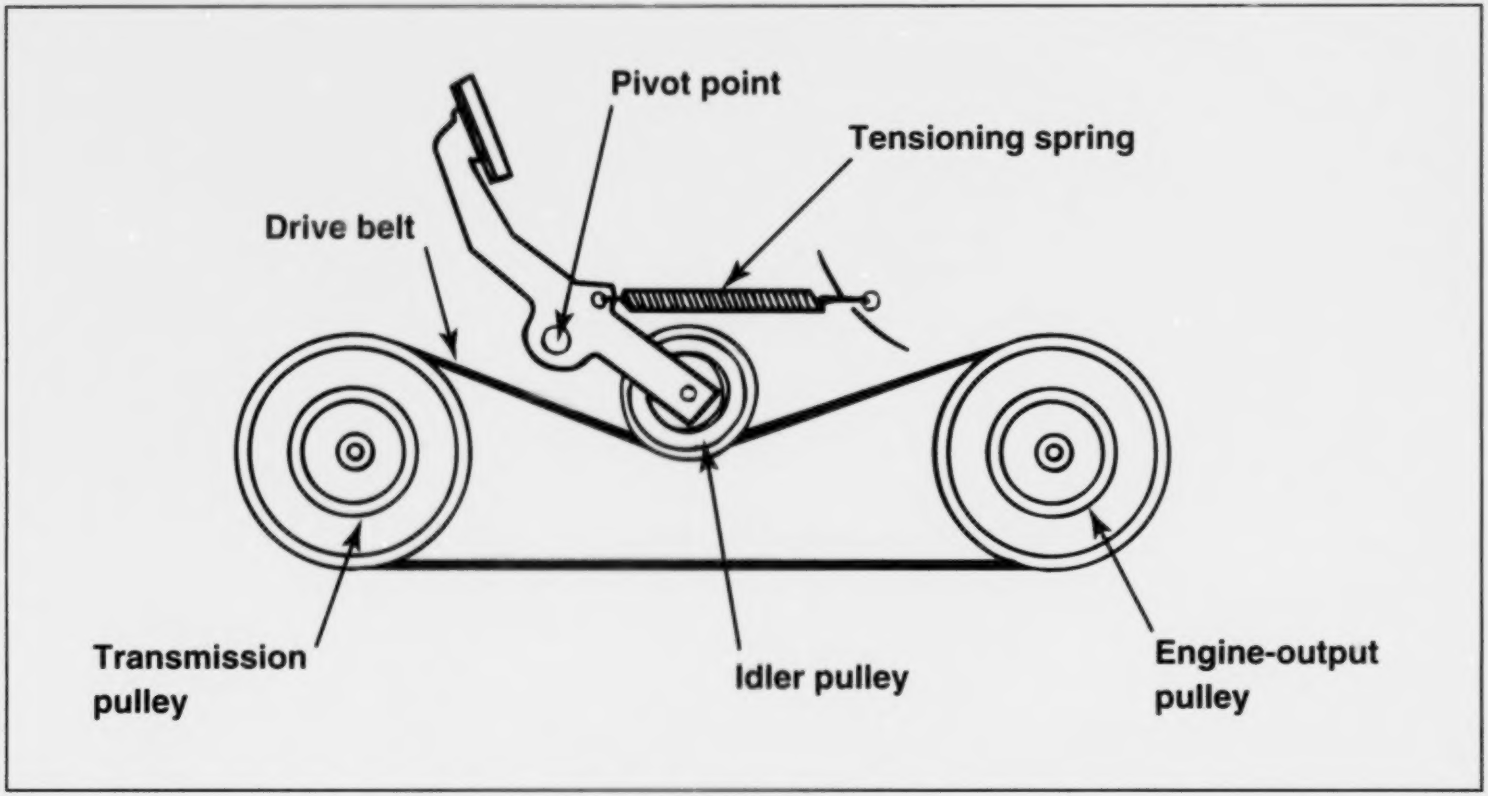
Telescoping Shaft


Attachment would be here.
Engine
Shaft spline
U-joints

Drawing reproduced by permission of EXCEL INDUSTRIES, Hustler Division, Heston, Kansas.

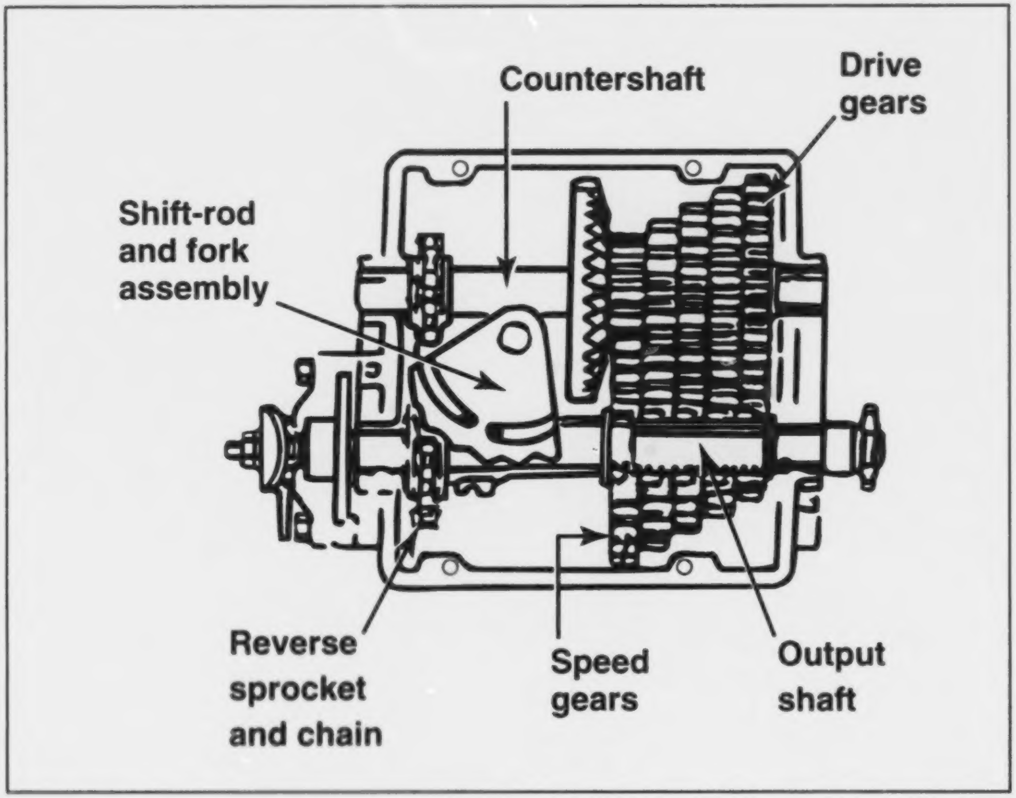
Types of Mechanical Drive Trains:

Typical Belt Drive Train

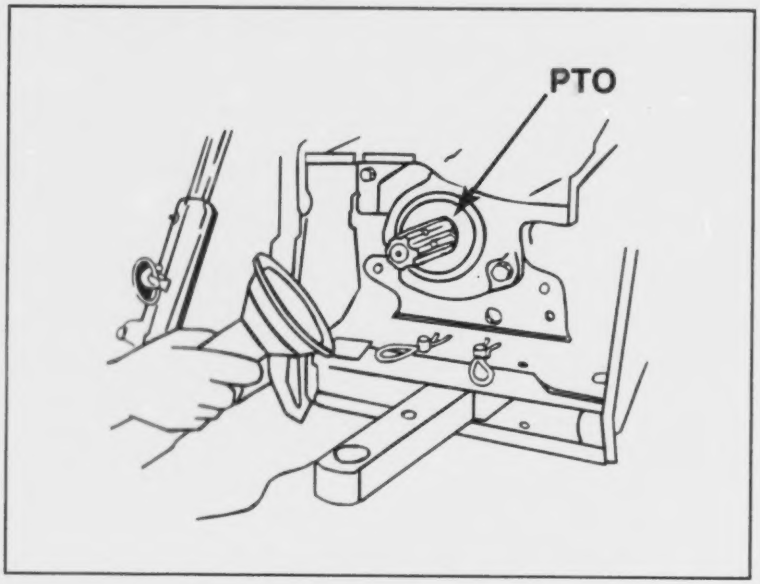

Pivot point
Tensioning spring
Drive belt
Transmission pulley
Idler pulley
Engine-output pulley

Types of Mechanical Drive Trains:

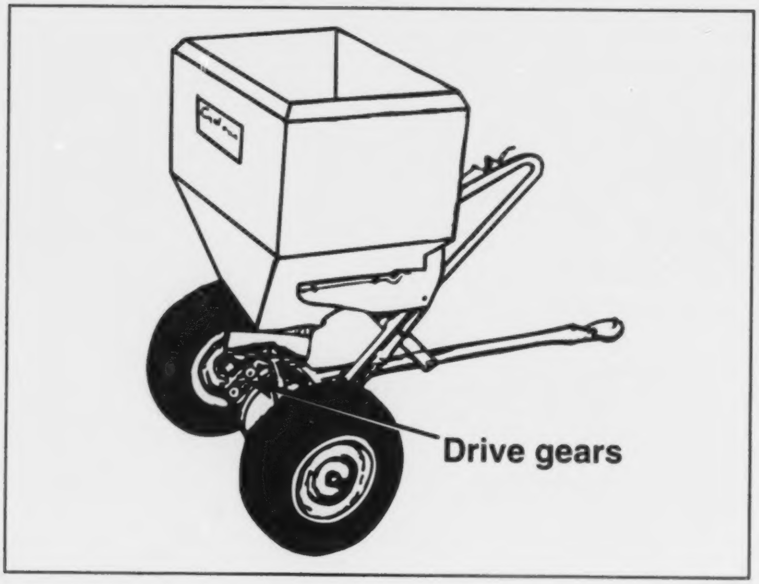
Typical Gear Drive Train


Countershaft
Drive gears
Shift-rod and fork assembly
Reverse sprocket and chain
Speed gears
Output shaft

Types of Mechanical Equipment Drives



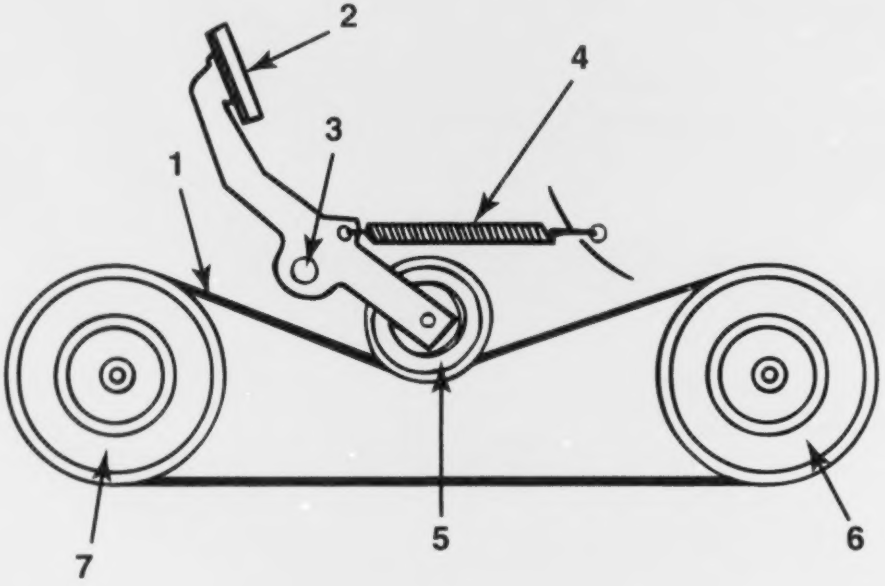
Mechanical PTO


Drive gears

Ground Drive

Types of Mechanical Clutch Systems:

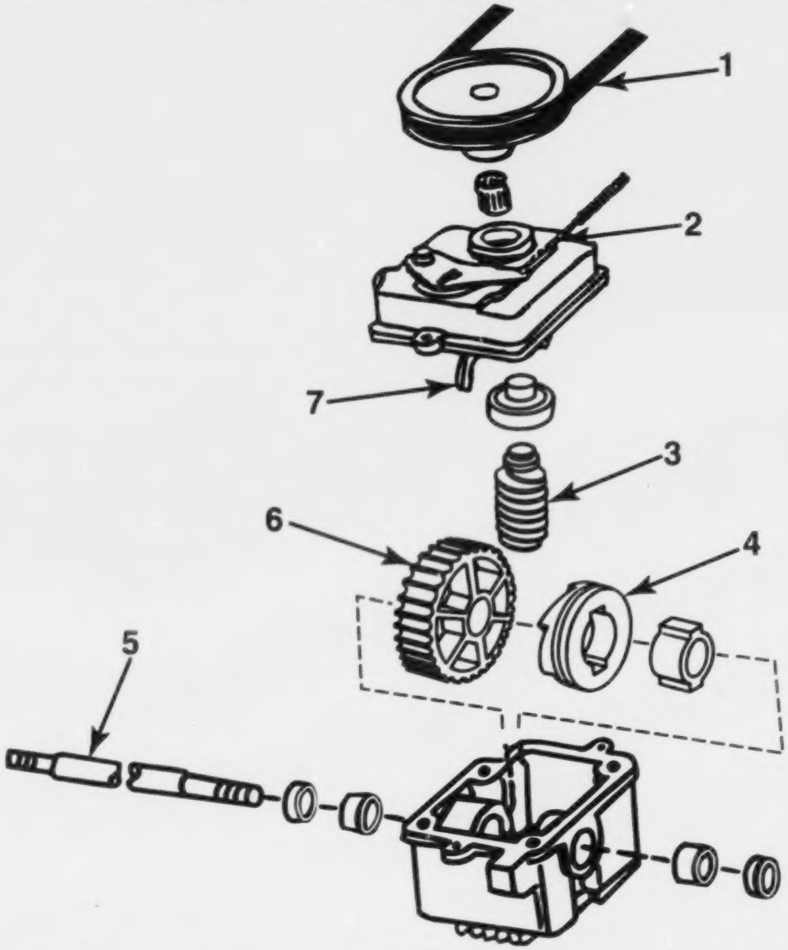
Belt Clutch



1. **Belt**
2. **Clutch pedal**
3. **Pivot point**
4. **Engaging spring**
5. **Idler pulley**
6. **Engine pulley**
7. **Drive pulley**

Types of Mechanical Clutch Systems:

Jaw Clutch



1. **Belt**
2. **Clutch control lever**
3. **Worm gear**
4. **Jaw clutch**
5. **Shaft**
6. **Drive gear**
7. **Shift fork**

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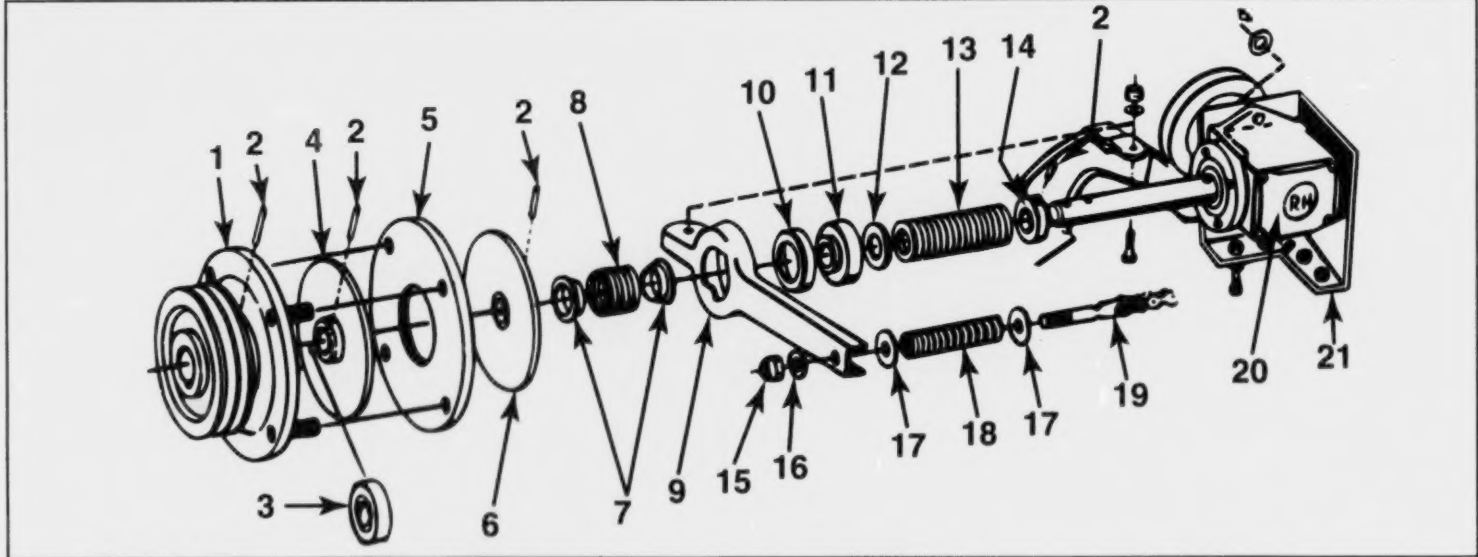
Types of Mechanical Clutch Systems:

Friction Clutch

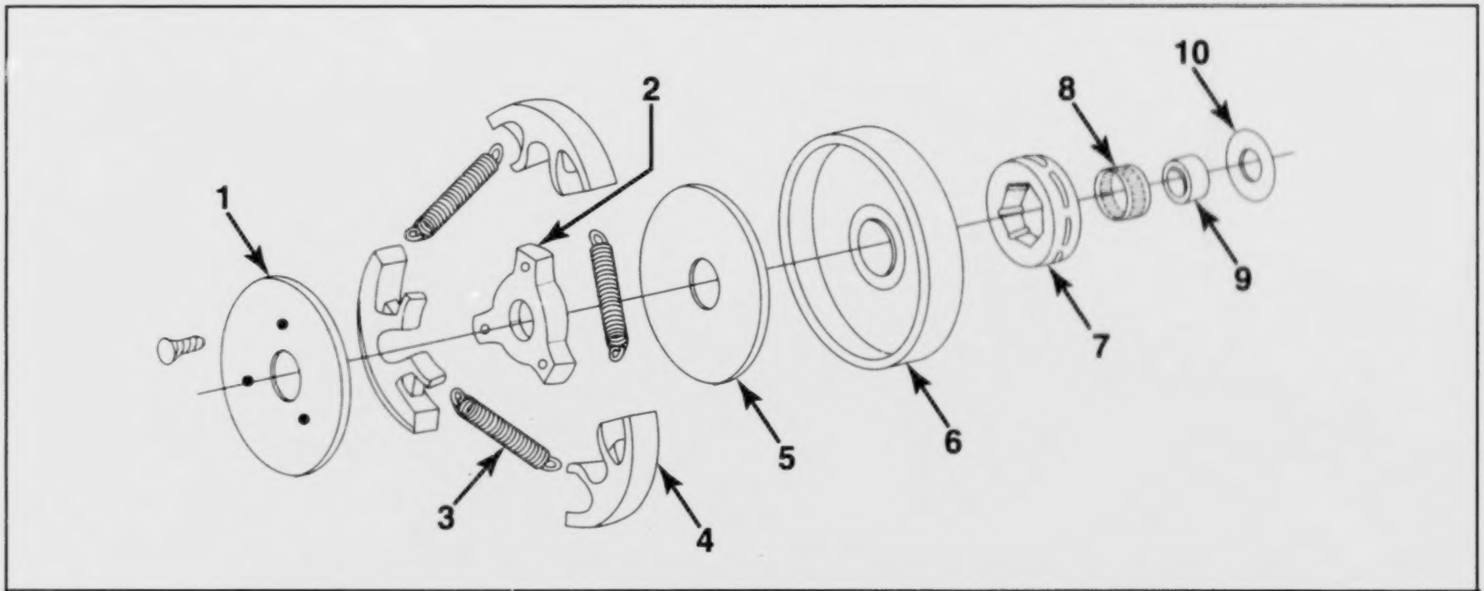


1. PTO drive and adapter
2. Roll pins
3. Bearing
4. Outer disc
5. Pressure plate
6. Inner disc
7. Spring guide
8. Spring
9. Clutch arm
10. Bearing cover
11. Bearing
12. Washer
13. Spring
14. Collar
15. Adjusting nut
16. Washer
17. Washer
18. Spring
19. Rod and chain
20. Right-angle drive unit
21. Bracket

Drawing reproduced by permission of Mike Barnett, MTD Products, Inc., Cleveland, Ohio.

Types of Mechanical Clutch Systems:

Centrifugal Clutch

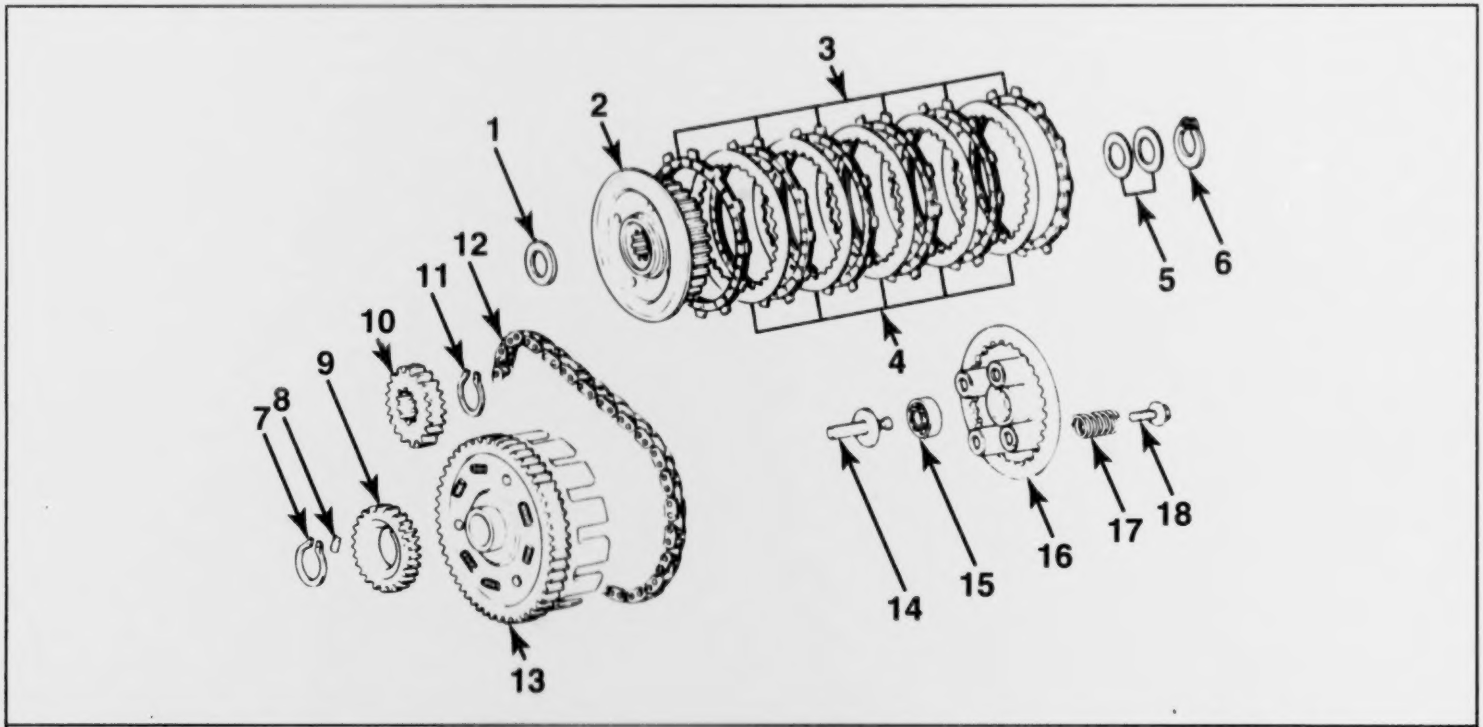


1. Cover plate
2. Hub
3. Spring
4. Shoe
5. Washer
6. Clutch drum
7. Sprocket
8. Bearing
9. Inner race
10. Washer

Drawing reproduced by permission of Textron Inc., Racine, Wisconsin.

Types of Mechanical Clutch Systems:

Multi-Disc Clutch



1. Thrust washer
2. Clutch hub
3. Friction plates
4. Steel plates
5. Shim(s)
6. Circlip
7. Circlip
8. Pin
9. Oil-pump drive gear
10. Primary sprocket
11. Circlip
12. Primary chain
13. Clutch housing
14. Spring-plate pusher
15. Ball bearing
16. Spring plate
17. Spring
18. Bolt

Drawing reproduced by permission of Kawasaki Motors Corporation, U.S.A., Irvine, California.

Equipment Systems, Unit 2
Teacher Page 85

TM 14

Job Sheet 1

Worksheet—Perform Routine Maintenance on Mechanical Drive Trains

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 1

Worksheet—Perform Routine Maintenance on Mechanical Drive Trains

---

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 2

Worksheet—Repair Mechanical Drive Trains

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ____

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________________

  Section/page number of procedure ____________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 2

Worksheet—Repair Mechanical Drive Trains

Part B: **Performance evaluation**

Evaluation criteria **Rating**

Correct procedures identified for assigned equipment. _____

Procedures completed correctly. _____

Proper tools used correctly. _____

Safety precautions observed. _____

Service meets specifications. _____

Clean-up and follow-up actions adequate. _____

Overall rating _____

Evaluator's comments ____

____

____

Job Sheet 3

Worksheet—Perform Routine Maintenance on Mechanical Equipment Drives

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

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Instructor's signature ______________________

Job Sheet 3

Worksheet—Perform Routine Maintenance on Mechanical Equipment Drives

---

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	
Procedures completed correctly.	
Proper tools used correctly.	
Safety precautions observed.	
Service meets specifications.	
Clean-up and follow-up actions adequate.	
Overall rating	

Evaluator's comments ______________________________

____

____

Job Sheet 4

Worksheet—Repair Mechanical Equipment Drives

Name Attempt number

Date

Part A: Pre-performance check

Job

- Complete the following information concerning the assigned equipment.

  Equipment brand

  Equipment model/type and code

- Complete the following service-manual information.

  Service-manual title

  Section/page number of procedure

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature

Job Sheet 4

Worksheet—Repair Mechanical Equipment Drives

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 5

Worksheet—Perform Routine Maintenance on Mechanical Clutch Systems

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 5

Worksheet—Perform Routine Maintenance on Mechanical Clutch Systems

---

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 6

Worksheet—Repair Mechanical Clutch Systems

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 6

Worksheet—Repair Mechanical Clutch Systems

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Principles of Fluid Power
Unit 3

Suggested Activities

Instructional plan

Preparation

- Review the unit in the student edition and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare the classroom by displaying posters, equipment, and tools related to hydraulic and pneumatic systems.
- Make transparencies from the transparency masters included in the teacher pages of this unit.
- Review Teacher Supplement 1, "Basics of Hydraulics," and decide how to best use this material with your students.
- Select teacher components (teacher supplement, written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution.
- Review the job sheets and worksheets in the student edition and locate the worksheet masters included in the teacher pages of this unit. Copy and prepare extra worksheets for distribution to your students.

Delivery and application

Unit introduction

The skill areas appearing in bold-face type in the unit introduction and teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want.* These have been adapted by MAVCC.

- Provide the students with the student edition of this unit. You may choose to begin by discussing the objective sheet. Review the unit and specific objectives with the students. Discuss how meeting the unit objective will improve students' employability or will increase their value as an employee. Explain how the specific objectives support the unit objective. **(Reading; listening; adapting to the organization's traditional modes of operation)**

Suggested Activities

- Introduce the unit by comparing hydraulic and pneumatic systems. Relate these concepts to topics that the students have mastered, such as fuel systems and the use of fuel pumps, venturi principles, suction and pressure in the movement of fluids, etc. Demonstrate the difference between liquids and gases in terms of compressibility. For example, the transmission of force can be demonstrated by the use of glass or plastic tubes with pistons installed in each end. If one tube is filled with air and the other with liquid, this principle can be shown, especially with U-shaped tubes. Such materials are often available through science supply houses and may be available in your facility if physics and similar subjects are taught. A simpler demonstration is possible using one balloon filled with air and one filled with water. Pushing against the air-filled balloon simply makes a depression, while pushing against the water-filled balloon changes the shape of the balloon. **(Listening; science; seeing things in the mind's eye; system interrelationships)**

Teaching suggestions

Objective 1 Complete statements concerning the basic concepts of physics related to fluid-power transmission.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Demonstrate each of the principles described. There are numerous kits, videotapes, and models available to demonstrate these principles. Otherwise, systems can be constructed of plastic pipe or other materials to illustrate the principles. The notes in the information sheet describe simple methods for demonstrating these concepts. Relate how the principles apply to power product equipment. **(Listening; reasoning; science; seeing things in the mind's eye; interpreting and processing information)**

- Relate the concepts to those that the students already understand. For example, if the students have completed *Power Product Equipment Technician: Theory and Principles of Engine Operation,* correlate hydraulic principles and components to the physics associated with internal-combustion engines. **(Listening; reasoning; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 2 Match types of fluid-power systems commonly used in power product equipment to their correct descriptions.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Demonstrate each type of fluid-power system in a purely theoretical way and then show how these systems are applied in power product equipment. For example, use an electric fan to show the effects of forced air, and then demonstrate the use of a power blower. During your demonstration, relate the basic concepts of physics you discussed in the previous objective. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

- Relate the types of fluid-power systems to concepts that the students already understand. For example, if the students have completed *Power Product Equipment Technician: Theory and Principles of Engine Operation,* correlate fluid-power systems and components to the operation of internal-combustion engines. **(Listening; reasoning; system interrelationships)**

Objective 3 State the functions of the major components of hydraulic systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 1, "Major Components of Hydraulic Systems," to aid the discussion. **(Reading/listening for content)**

- Provide examples of actual equipment to demonstrate the role of hydraulic components and their functions in given systems. Show a variety of component types, such as vented and nonvented reservoirs, various types of pumps, different cylinder configurations, etc. Point out similarities and differences in the systems. **(Listening; reasoning; science; seeing things in the mind's eye; system interrelationships)**

- Discuss variations in hydraulic-system design, including accumulators. Relate variations to applications in power product equipment. Describe the two major types of systems used in power product equipment: displacement systems and circulating systems. **(Listening; reasoning; science; seeing things with the mind's eye; system interrelationships)**

Objective 4 Identify common symbols used on hydraulic diagrams.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 2, "Common Symbols Used on Hydraulic Diagrams," to aid the discussion. **(Reading/listening for content)**

- Provide examples of hydraulic flow diagrams and point out the symbols used on the diagrams. Explain that flow diagrams are often more pictorial than symbolic because hydraulics is just one aspect of power product equipment service. Show examples of both pictorial and symbolic flow diagrams. Help the students to relate aspects of the symbols to the actual physical characteristics of components to improve their grasp of the symbols. Add or delete symbols as appropriate to support the types of equipment and resource materials emphasized in your program. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 5 Match types of hydraulic fluids used in power product equipment to their correct descriptions.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

Suggested Activities

- Discuss reasons for the need for different types of fluid, including fluid characteristics such as viscosity, resistance to heat breakdown, antifoaming properties, etc. Discuss the role of fluids as coolants and lubricants in hydraulic systems. Display samples of the different types of fluids and oils. Review service manuals that specify types of fluids and system capacities. Discuss filters and cooling systems. Point out service procedures for checking fluid levels (engine running and in neutral, engine off, fluid heated to normal operating temperature, etc.) and refill procedures (transmission in neutral, fill differential separately, etc.). Present samples of unacceptable fluids, such as those discolored by age or overheating, contaminated fluids, etc. Describe system problems and symptoms that can result from incorrect fluids, defective fluids, or low fluid levels. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information)**

Objective 6 State safety rules for working with hydraulic systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use your discussion of types of hydraulic fluids to introduce safety concerns and precautions. Discuss handling and storage of fluids and safety precautions for flammability, toxicity, etc. Demonstrate the proper way to check high-pressure lines for leaks. Remind students of the locations of eye-wash stations and other first-aid facilities and how to use them. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 7 State guidelines for preventing equipment damage when working with hydraulic systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use your discussion of safety precautions related to hydraulic fluids to introduce equipment-damage concerns. Demonstrate the connection and disconnection of various types of hoses, lines, and connectors. Discuss the effects of contaminants on hydraulic fluids and their performance. Exhibit damage to paint and other finishes caused by hydraulic fluids. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 8 List types of power product equipment that use hydraulic power.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use illustrations as well as actual equipment to provide examples of the various types of power product equipment that use hydraulic power. Show a variety of system applications. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

Objective 9 List applications of hydraulic systems in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use illustrations as well as actual equipment to provide examples of the various applications of hydraulics in power product equipment. Lead the students in brainstorming to identify applications. Include accessories and individual components, such as shock absorbers, add-on lift systems, hydraulic mowers, etc. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 10 Identify types of hydraulic pumps.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparencies 3 through 6 to aid the discussion. **(Reading/listening for content)**

- Provide actual examples of each type of hydraulic pump, including cutaways if possible. Briefly describe the operation of each type of hydraulic pump, as this will be covered in detail in Objectives 12 through 15. Discuss advantages and disadvantages of each type as related to specific applications. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 11 State functions of the major components of hydraulic pumps.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 7, "Major Components of Hydraulic Pumps," to aid the discussion. **(Reading/listening for content)**

- Discuss the function of each component in terms of accomplishing its purpose within a hydraulic system. Provide actual equipment and use a variety of types of pumps to show corresponding components. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 12 Complete statements about the principles of operation of centrifugal hydraulic pumps.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use Transparency 3, "Types of Hydraulic Pumps: Centrifugal," and actual equipment to aid your discussion. Use a bucket of water or a small weight on a record turntable to illustrate centrifugal force. Explain how these forces are applied in a pump. Relate physics concepts to the operation of centrifugal pumps. Discuss the advantages and disadvantages of centrifugal pumps in specific applications. Relate specific service procedures for centrifugal pumps. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Suggested Activities

Objective 13 Complete statements about the principles of operation of rotary hydraulic pumps.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use Transparency 4, "Types of Hydraulic Pumps: Rotary," and actual equipment to aid your discussion. Use as many design variations of rotary pumps as possible. For example, show a variety of drive mechanisms, such as vanes, gears, gerotors, etc. Discuss the principles of physics at work in each. Discuss reasons for arranging components such as inlet and outlet ports in specific ways. Discuss the advantages and disadvantages of each type of rotary pump in specific applications. Relate specific service procedures to each type of pump. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 14 Complete statements about the principles of operation of diaphragm hydraulic pumps.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use Transparency 5, "Types of Hydraulic Pumps: Diaphragm," and actual equipment to aid your discussion. The students should understand the principles of operation of diaphragm pumps because of their study of fuel systems. Build on this knowledge as you discuss diaphragm hydraulic pumps. Discuss the advantages and disadvantages of diaphragm pumps in specific applications. Relate specific service procedures to this type of pump. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 15 Complete statements about the principles of operation of piston hydraulic pumps.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use Transparency 6, "Types of Hydraulic Pumps: Piston," and actual equipment to aid your discussion. For each type of piston pump, use as many design variations as possible. For example, when discussing axial piston pumps, include pumps that use swashplates and wobble plates, pistons with shoes and without, hollow and solid trunnions, etc. Discuss the reason for having odd numbers of pistons in radial and axial piston pumps. Discuss the advantages and disadvantages of each type of piston pump in specific applications. Relate specific service procedures to this type of pump. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Suggested Activities

Objective 16 List typical service procedures required for hydraulic systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Provide equipment, tools, and service manuals to support your discussion of the service procedures typically required for hydraulic systems. Display wall charts related to the service procedures. Point out comparable procedures for different types of hydraulic systems. Emphasize those procedures that will be covered in your presentation of the job sheets and perform relevant demonstrations. Tailor the procedures to the type of equipment and tools available in your facility. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; applying technology; system interrelationships)**

Objective 17 Identify specialty tools used to perform hydraulic-system service.

- Read and discuss with students the information presented in this section of the information sheet. Use actual tools to assist the discussion. Relate tools to service procedures discussed in the previous objective and to specific equipment. Discuss and demonstrate the construction of technician-made tools, such as transmission stands, gear pullers, forks for removing Eaton body and motor assemblies, etc. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 18 State the functions of the major components of pneumatic systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 8, "Major Components of Pneumatic Systems," to aid the discussion. **(Reading/listening for content)**

- Discuss variations in pneumatic-system design, including accumulators. Relate design variations to applications in power product equipment. Describe the two major types of pneumatic systems used in power product equipment: open and closed systems. **(Listening; reasoning; science; seeing things with the mind's eye; system interrelationships)**

Objective 19 Identify common symbols used on pneumatic diagrams.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 9, "Common Symbols Used on Pneumatic Diagrams," to aid your discussion. **(Reading/listening for content)**

Suggested Activities

- Provide examples of the pneumatic flow diagrams and point out the symbols used on the diagrams. Explain that flow diagrams are often more pictorial than symbolic because pneumatics is just one aspect of power product equipment service. Show examples of both pictorial and symbolic of flow diagrams. Help the students to relate aspects of the symbols to the actual physical characteristics of components to improve their grasp of the symbols. Add or delete symbols as appropriate to support the types of equipment and resource materials emphasized in your program. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 20 State safety rules for working with pneumatic systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use your discussion of types of pneumatic systems to introduce safety concerns and precautions. Discuss handling of hoses and connectors. Discuss the dangers of flying objects and debris driven by air under pressure. Demonstrate the proper way to check high-pressure lines for leaks. Remind students of the locations of eye-wash stations and other first-aid facilities and how to use them. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 21 State guidelines for preventing equipment damage when working with pneumatic systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Display examples of stripped connectors, ruptured hoses, bent impellers, and other equipment damaged through improper handling and service. Demonstrate specific procedures for working with equipment in your facility. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 22 List types of power product equipment that use pneumatic power.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use actual equipment to provide examples of the various types of power product equipment that use pneumatic power. Show a variety of system applications. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Suggested Activities

Objective 23 List applications of pneumatic systems in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Use actual equipment to provide examples of the various applications of pneumatics in power product equipment. Lead the students in brainstorming to identify applications. Include accessories and individual components, such as shock absorbers, add-on lift systems, sprayers, etc. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 24 Identify types of pneumatic pumps.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparencies 10 through 13 to aid your discussion. **(Reading/listening for content)**
- Provide actual examples of each type of pneumatic pump, including cutaways if possible. Briefly describe the operation of each type of pneumatic pump, as this will be covered in detail in Objectives 26 through 29. Discuss advantages and disadvantages of each type as related to specific applications. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 25 State functions of the major components of pneumatic pumps.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 14, "Major Components of Pneumatic Pumps," to aid your discussion. **(Reading/listening for content)**
- Discuss the function of each component in terms of accomplishing its purpose within a pneumatic system. Display a variety of types of pumps and show the corresponding components in the various designs. Relate these components to similar components in hydraulic systems. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 26 Complete statements about the principles of operation of centrifugal pneumatic pumps.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Use Transparency 10, "Types of Pneumatic Pumps: Centrifugal," and actual equipment to aid your discussion. Explain how centrifugal force is applied in a centrifugal pneumatic pump. Relate physics concepts to the operation of centrifugal pumps. Discuss the advantages and disadvantages of centrifugal pumps in specific applications. Show a variety of impellers. Relate specific service procedures to centrifugal pumps. Compare and contrast the design and operation of centrifugal pumps in hydraulic systems. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Suggested Activities

Objective 27 Complete statements about the principles of operation of propeller pneumatic pumps.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use Transparency 11, "Types of Pneumatic Pumps: Propeller," and actual equipment to aid your discussion. There are numerous systems available for showing airstreams through propellers, or you can set up a demonstration using low-speed fans and smoke. Discuss methods for controlling the speed and direction of airflow. Discuss the advantages and disadvantages of propeller pumps in specific applications. Relate specific service procedures to this type of pump. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 28 Complete statements about the principles of operation of diaphragm pneumatic pumps.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use Transparency 12, "Types of Pneumatic Pumps: Diaphragm," and actual equipment to aid your discussion. The students should understand the principles of operation of diaphragm pumps because of their study of fuel systems. Build on this knowledge through the use of pneumatic systems. Discuss the advantages and disadvantages of diaphragm pumps in specific applications. Relate specific service procedures to this type of pump. Compare and contrast the design and operation of similar pumps in hydraulic systems. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 29 Complete statements about the principles of operation of reciprocating pneumatic pumps.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use Transparency 13, "Types of Pneumatic Pumps: Reciprocating," and actual equipment to aid your discussion. The students should be familiar with common reciprocating-pump designs as a result of their studies of internal-combustion engines. Discuss the role and operation of valves in such systems. Discuss the advantages and disadvantages of reciprocating pumps in specific applications. Relate specific service procedures to this type of pump, emphasizing daily and frequent service requirements such as tank and filtering draining. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Suggested Activities

Objective 30 List typical service procedures required for pneumatic systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Provide equipment, tools, and service manuals to support your discussion of service procedures. Display wall charts related to the service procedures. Point out comparable procedures for different types of pneumatic systems. Emphasize those procedures that will be covered in your presentation of the job sheets and perform relevant demonstrations. Tailor the procedures to the type of equipment and tools available in your facility. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; applying technology; system interrelationships)**

Objective 31 Identify specialty tools used to perform pneumatic-system service.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Provide actual tools to aid the discussion. Relate tools to the service procedures discussed in the previous objective and to specific equipment. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Assignment Sheet 1 Interpret flow diagrams and assembly drawings.

- Have students locate Assignment Sheet 1. Read the introduction and directions to the assignment. **(Reading/listening for direction)**

- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Listening; reasoning; writing; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

- Answer any student questions and have students complete Assignment Sheet 1.

Job Sheet 1 Measure hydraulic-system temperature.

- Have students locate Job Sheet 1 and the worksheet associated with the job sheet. Demonstrate the procedures for measuring hydraulic-system temperature. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

Suggested Activities

- Provide students with power product equipment that allows measuring of the hydraulic-system temperature and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 1.

Job Sheet 2 Measure hydraulic-system pressure.

- Have students locate Job Sheet 2 and the worksheet associated with the job sheet. Demonstrate the procedures for measuring hydraulic-system pressure. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment that allows measuring of the hydraulic-system pressure and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 2.

Job Sheet 3 Measure hydraulic-system flow.

- Have students locate Job Sheet 3 and the worksheet associated with the job sheet. Demonstrate the procedures for measuring hydraulic-system flow. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment that allows measuring of hydraulic-system flow, and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 3.

Job Sheet 4 Measure air pressure.

- Have students locate Job Sheet 4 and the worksheet associated with the job sheet. Demonstrate the procedures for measuring air pressure. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment with a pneumatic system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 4.

Job Sheet 5 Measure airflow.

- Have students locate Job Sheet 5 and the worksheet associated with the job sheet. Demonstrate the procedures for measuring airflow. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

Suggested Activities

- Provide students with power product equipment with a pneumatic system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 5.

Evaluation

- Evaluate the assignment sheet. See the evaluation criteria listed at the top of each assignment sheet as well as the teacher page "Answers to Assignment Sheet."

- Evaluate the job sheets.

  When the student is ready to perform a specific task, obtain a copy of the worksheet associated with each job sheet. Worksheets may be found in the student edition and in the teacher pages following the transparency masters. Then, observe the student performing the procedure.

  After the student has completed the procedure, rate the student using the criteria provided on the worksheet. If the student's performance is unacceptable, have the student review the materials and perform the procedure again for evaluation.

  Two sample performance evaluation keys are provided below. Many other keys are available. Select one evaluation key (grading scale) that best fits your program needs.

Performance Evaluation Keys

Sample A

4 — Skilled—Can perform job with no additional training.
3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
1 — Unskilled—Is familiar with process, but is unable to perform job.

Sample B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

- Give the written test. See the teacher page "Written Test."

- Evaluate the written test. See the teacher page "Answers to Written Test."

- Compile written-test, assignment-sheet, and job-sheet scores. See the teacher page "Unit Evaluation Form."

- Reteach and retest as required.

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Suggested Activities

Suggested resources

Resources used in developing this unit

Print media

- Graf, Rudolf F., and George J. Whalen. *VNR Illustrated Guide to Power Tools.* New York: Van Nostrand Reinhold Company, 1978.
- Hawker, M. F. J., and J. F. Keenlyside. *Horticultural Machinery,* 3rd ed. Essex, England: Longman Group Limited, 1985.
- Hedges, Charles S. *Industrial Fluid Power,* 3rd ed. Dallas, Texas: Womack Educational Publications, 1984.
- Jorgensen, Eric, editor. *Kawasaki 250-750cc Triples,* 5th ed. Arleta, California: Clymer Publications, 1979.
- *MTD Yard-Man Technical Service Handbook.* Cleveland, Ohio: MTD Products, Inc., 1996.
- *Outdoor Power Equipment Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1985.
- *Power Tools and Equipment.* Alexandria, Virginia: Time-Life Books, Inc., 1989.
- *Power Trains: Compact Equipment.* Moline, Illinois: Deere and Company, 1991.
- *Riding Lawn Mower Service Manual,* 3rd ed. Overland Park, Kansas: Intertec Publishing Corporation, 1989.
- *Small Tractor Service Manual.* Overland Park, Kansas: Intertec Publishing Corporation, 1984.
- Stewart, Harry L. *Hydraulics for Off-the-Road Equipment.* Indianapolis, Indiana: Theodore Audel and Co., 1978.
- Wright, Ron. *Harley-Davidson Sportsters,* 7th ed. Arleta, California: Clymer Publications, 1986.
- *Yard and Garden Tractor Service Manual,* 1st ed. Overland Park, Kansas: Intertec Publishing Corporation, 1992.

Suggested supplemental resources

Print media

- *Outdoor Power Equipment* magazine. Adams/Green Industry Publishing, 68860 Perez Road, Suite J, Cathedral City, California 92234. Web site: http://www.outdoorpowerequipment.com
- *Power Equipment Trade* magazine. Hatton-Brown Publishers, Inc., P. O. Box 2268, Montgomery, Alabama 36102.

Suggested Activities

- *Technical Handbook*. Describes the makes and types of equipment produced by MTD—one of the nation's largest manufacturers. The book covers service for most equipment systems and various types of equipment. Both light- and heavy-duty equipment types are included. Available from MTD Products, Inc. Call 1-800-422-3381.
- Service manuals for systems covered in this unit.
- Parts catalogs for systems covered in this unit. Available from equipment manufacturers.

Non-print media

- *Centrifugal Pump Maintenance*. Arthur Mokin Productions, P.O. Box 1866, Santa Rosa, California 95402, (707) 542-4868.
- *Centrifugal Pump Operation*. L and K International Videotraining, P.O. Box 940 Station U, Toronto, Ontario M8Z 5P9, Canada, (416) 252-6407.
- *Centrifugal Pumps*. Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Cub Cadet 3000 Series Seven In One Tape*. While this videotape covers engine and transmission service, it also provides information about hydrauic theory and hydraulic line replacement. Thus, portions can be used in this unit or with Unit 4 or with *Lawn and Garden Equipment*, Unit 3. Available from MTD Products, Inc. Call 1-800-422-3381.
- *Energy Transmission Using a Pneumatic System*. Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Force Transmission Through a Fluid*. Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Gear Pumps and Vane Pumps*. L and K International Videotraining, P.O. Box 940 Station U, Toronto, Ontario M8Z 5P9, Canada, (416) 252-6407.
- *Hydraulic Equipment*. Industrial Training Corporation, 13515 Dulles Technology Drive, Herndon, Virginia 22070, (800) 638-3757.
- *Hydraulic Motors*. Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Hydraulic Transmission of Force and Energy*. Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Operation at the Suction Side of the Pump*. Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.

Suggested Activities

- *The Physical World of a Machine.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Pump Operations.* Industrial Training Corporation, 13515 Dulles Technology Drive, Herndon, Virginia 22070. (800) 638-3757.

Principles of Fluid Power
Unit 3

Answers to Assignment Sheet

Assignment Sheet 1—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1. a. Reservoir oil
   b. Piston pump

2. a. Reservoir oil
   b. Charge and auxiliary roll pump
   c. Yes

3. a. Brake fluid or alcohol
   b. 16
   c. 5
   d. (Hand) lever
   e. Displacement

4. a. 11
   b. Spool (Item 11)
   c. 3
   d. Nut (Item 2)
   e. Snap ring (Item 7)

5. a. Oil under suction
   b. Charge pump
   c. Axial-piston pump
   d. Gerotor
   e. Just after

Principles of Fluid Power
Unit 3

Answers to Written Test

1.
   a. flow
   b transmit
   c. compresses; compressed
   d. does not
   e. high; lower
   f. lower; increases
   g. increases
   h. pressure

2.
   a. 2
   b. 3
   c. 1
   d. 4
   e. 5

3.
   a. Holds the fluid that is not in use in other parts of the system
   b. Moves the fluid from the reservoir to the rest of the system and provides pressure to the system
   c. Provides a means for the operator to control the operation of the hydraulic system
   d. Connect the parts of the system and hold the fluid
   e. Houses the piston and holds the fluid
   f. Moves in response to fluid pressure or actuator operation to produce the mechanical or fluid movement
   g. Control the routing of the fluid through the system in response to differences in pressure or mechanical adjustments

4.
   a. Reservoir
   b. Actuator
   c. Cylinder
   d. Pump
   e. Piston
   f. Motor
   g. Shutoff valve
   h. Check valve
   i. Cylinder

5.
   a. 4
   b. 1
   c. 2
   d. 5
   e. 6
   f. 3

6.
   a. Do not expose hydraulic fluids to flames, sparks, or heat.
   b. Remove pressure on a hydraulic system before working on any system component.
   c. Be careful when working with hydraulic seals and hoses that may cause the technician to come in contact with hot, high-pressure hydraulic fluids.
   d. Use a light cloth or sheet of paper to locate hydraulic-system leaks; do not use your hands.

Answers to Written Test

7. a. Make sure that connections are correct and tight before pressurizing a hydraulic system.
   b. Do not reuse fluids that have been drained from a hydraulic system.
   c. Do not contaminate hydraulic fluids with dirt or oils.
   d. Bleed air from the system as recommended by the manufacturer after service.
   e. Do not allow fluids to contact painted or plastic surfaces.

8. Answers may appear in any order.

   - Self-propelled equipment
   - Lift equipment
   - Ram equipment
   - Independent hydraulic attachments

9. Answers should include any four of the following.

   - Brake systems
   - Hydrostatic transmissions/transaxles
   - Power-steering systems
   - Lift systems
   - Ram systems
   - Hydraulic equipment drives
   - Shock-dampening systems

10. a. Diaphragm
    b. Centrifugal
    c. Rotary/gerotor
    d. Rotary/vane
    e. Rotary/gear
    f. Piston/axial
    g. Piston/radial
    h. Piston/ball

11. a. Allows fluid to enter the pump
    b. Houses the pump components
    c. Provides the power for pump operation
    d. Produces movement in the fluid
    e. Allows fluid to exit the pump

12. a. rotational
    b. rotational; pump
    c. centrifugal
    d. pressure

13. a. rotational
    b. rotational; wheel
    c. narrower
    d. decrease

Answers to Written Test

14. a. reciprocating
    b. volume
    c. increases
    d. decreases

15. a. pump
    b. pistons
    c. cylinder
    d. increases
    e. pump
    f. decrease

16. Answer should include any three of the following.

- Measure fluid temperature
- Measure system pressure
- Measure flow
- Bleed the system
- Flush the system
- Replace seals
- Replace hoses and lines

17. Answers may appear in any order.

- Pressure gauge
- Thermometer
- Fluid flow meter

18. a. Holds air under pressure
    b. Moves air under pressure into the reservoir
    c. Provides a means for the operator to control the operation of the pneumatic system
    d. Connect the parts of the system and hold the pressurized air, or direct moving air
    e. Houses the piston
    f. Moves in response to an outside power source to take air into the cylinder, compress it, and force it into the reservoir
    g. Control the routing of air through the system in response to differences in pressure or mechanical adjustments

19. a. Cylinder
    b. Reservoir
    c. Check valve
    d. Actuator
    e. Shutoff valve
    f. Cylinder
    g. Motor
    h. Piston
    i. Pump

Answers to Written Test

20. a. Do not direct airstreams toward yourself or other persons.
    b. Remove air pressure before working on any system components.
    c. Be careful when working with pneumatic hoses and seals.
    d. Use a light cloth or sheet of paper to locate pneumatic-system leaks; do not use your hands.
    e. Never use oxygen or other pressurized gases in place of compressed air.

21. a. Make sure that connections are correct and tight before pressurizing a pneumatic system.
    b. Do not contaminate pneumatic hoses, connectors, or reservoirs with dirt, grease, water, or any other contaminant.

22. Answers may appear in any order.

- Lawn mowers
- Snow blowers
- Leaf blowers
- Sprayers
- Lawn vacuums

23. Answers may appear in any order.

- Air compressors
- Suspension systems

24. a. Diaphragm
    b. Centrifugal
    c. Propeller
    d. Reciprocating

25. a. Allows air to enter the pump
    b. Houses the pump components
    c. Drives the pump mechanism
    d. Moves air through the system
    e. Allows air to exit the pump

26. a. pump
    b. impeller
    c. Extensions
    d. center

27. a. mechanical
    b. angle
    c. low-pressure
    d. low-pressure
    e. air

Answers to Written Test

28. a. reciprocating
    b. volume
    c. increases
    d. decreases

29. a. engine
    b. low
    c. outside
    d. piston
    e. piston; pressure
    f. inlet; piston; outlet
    g. piston; cylinder
    h. decrease; outlet; inlet

30. Answer should include any four of the following.

- Lubricate moving parts
- Measure system pressure
- Measure flow
- Drain water from the system
- Drain filters
- Replace filters
- Replace seals
- Replace hoses and lines

31. Answers may appear in any order.

- Pressure gauge
- Airflow meter

Principles of Fluid Power
Unit 3

Written Test

Name ______________________________ Score ______________

1. Complete statements concerning the basic concepts of physics related to fluid-power transmission. Write the missing word(s) on the blanks provided in the statements below.

   a. A fluid is a substance that can ______________ at the molecular level; there are two types of fluids—gases and liquids.

   b. Fluid power is the use of a fluid to ______________ power.

   c. Gas in a container ______________ when pressure is applied to the gas, and the ______________ gas exerts a force on its container in all directions equal to the pressure that has been applied.

   d. A liquid in a container ______________ compress when pressure is applied to the liquid; pressure applied to a liquid is transmitted throughout the liquid.

   e. Fluids flow from areas of ______________ pressure to areas of ______________ pressure.

   f. A fluid in motion creates an area of ______________ pressure; the pressure differential ______________ as the flow rate of the fluid increases.

   g. If a fluid under pressure is forced through an area of smaller volume, the flow rate of the fluid ______________.

   h. By controlling the amount of pressure in a system and the system's response to the ______________, you can multiply or reduce the amount of force transmitted in the system and increase or decrease the system's rate of output.

Written Test

2. Match types of fluid-power systems commonly used in power product equipment to their correct descriptions. Write the numbers on the blanks.

_______ a. System that uses air stored at a pressure greater than the pressure of the surrounding atmospheric air

_______ b. System that uses moving air that is made to move through the use of fans, blowers, impellers, and similar devices

_______ c. System that uses air that is at a pressure less than the pressure of the surrounding atmospheric air

_______ d. System that uses moving liquids that are not recirculated

_______ e. System that uses stationary liquids or uses moving liquids that are not recirculated

1. Air-suction system
2. Compressed-air system
3. Forced-air system
4. Hydrodynamic system
5. Hydrostatic system

3. State the functions of the major components of hydraulic systems. Write your answers on the blanks provided beside each of the components listed below.

a. Reservoir ____

____

b. Pump ____

____

c. Actuator ____

____

d. Lines ____

____

e. Cylinder ____

____

f. Piston ____

____

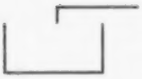
g. Valves ____

____

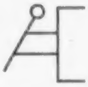
Written Test

4. Identify common symbols used on hydraulic diagrams. Select your answers from the following list, and then write your answers on the blanks provided under each of the illustrations below. Some answers may be used more than once.

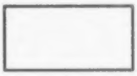
Reservoir
Pump
Actuator
Cylinder
Piston
Check valve
Shutoff valve
Motor



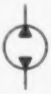
a. ______________________________



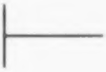
b. ______________________________



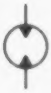
c. ______________________________



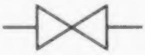
d. ______________________________



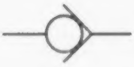
e. ______________________________



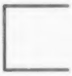
f. ______________________________



g. ______________________________



h. ______________________________



i. ______________________________

Written Test

5. Match types of hydraulic fluids used in power product equipment to their correct descriptions. Write the numbers on the blanks.

________ a. Fluid normally used in mechanical-drive systems of some lift systems and in hydraulic motors

________ b. Fluid specifically formulated for hydrostatic transmissions but also used in some lift systems and some power-steering systems

________ c. Fluid that meets Department of Transportation specifications for use in automotive brake systems and is also used in power product equipment brake systems

________ d. Fluid specifically formulated for power-steering systems

________ e. Fluid specifically recommended by an equipment manufacturer because it has been designed to meet the exact specifications of an application of a piece of equipment

________ f. Fluid normally used as an engine lubricant and is also sometimes used in some hydraulic motors

1. Automatic-transmission fluid
2. Brake fluid
3. Crankcase oil
4. Hydraulic oil
5. Power-steering fluid
6. Special-application oil

6. State safety rules for working with hydraulic systems. Write the complete safety rule on the blanks provided beside each of the terms below.

a. Flames, sparks, or heat ____

____

b. Removing pressure ____

____

c. Working with seals and hoses ____

____

d. Locating hydraulic-system leaks ____

____

7. State guidelines for preventing equipment damage when working with hydraulic systems. Write the complete guideline on the blanks provided beside each of the terms below and on the next page.

a. Before pressurizing a hydraulic system ________________________________

____

b. Reusing drained fluids ____________________

c. Contaminating hydraulic fluids ____________________

d. Bleeding air from the system ____________________

e. Contacting painted or plastic surfaces ____________________

8. List types of power product equipment that use hydraulic power. Write your answers on the blanks provided.

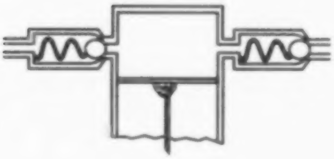
a. ____________________
b. ____________________
c. ____________________
d. ____________________

9. List four applications of hydraulic systems in power product equipment. Write your answers on the blanks provided.

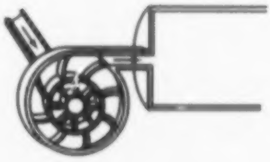
a. ____________________
b. ____________________
c. ____________________
d. ____________________

10. Identify types of hydraulic pumps. Select your answers from the following list, and then write your answers on the blanks provided under each of the illustrations below and on the next page.

Centrifugal
Rotary/vane
Rotary/gear
Rotary/gerotor
Diaphragm
Piston/axial
Piston/radial
Piston ball

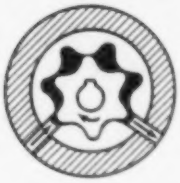


a. ____________________

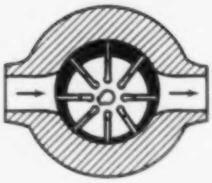


b. ____________________

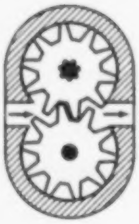
Written Test



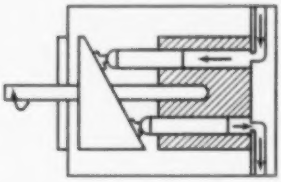
c. ______________________________



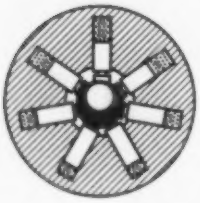
d. ______________________________



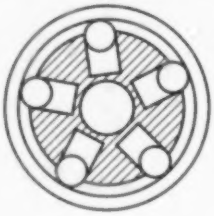
e. ______________________________



f. ______________________________



g. ______________________________



h. ______________________________

11. State functions of the major components of hydraulic pumps. Write your answers on the blanks provided beside each of the components listed below.

    a. Inlet port ______________________________

    ____

    b. Pump body ______________________________

    ____

    c. Input shaft ______________________________

    ____

    d. Impeller ______________________________

    ____

    e. Outlet port ______________________________

    ____

Written Test

12. Complete statements about the principles of operation of centrifugal hydraulic pumps. Write the missing word(s) on the blanks provided in the statements below.

    a. An outside source, such as an engine, provides ____________________ force that is transmitted to the pump.

    b. The ____________________ force causes an impeller within the ____________________ to turn.

    c. The impeller moves fluid near its axis, and ____________________ force causes the fluid to move toward the outside edge of the impeller and through the outlet.

    d. The changes in ____________________ caused by the moving fluid allow additional fluid to flow into the pump through an inlet opening.

13. Complete statements about the principles of operation of rotary hydraulic pumps. Write the missing word(s) on the blanks provided in the statements below.

    a. An outside source, such as an engine, provides ____________________ force that is transmitted to the pump.

    b. The ____________________ force causes a ____________________, such as a gear, within the pump to turn.

    c. The turning gear moves fluid and pushes it from an open area of the pump body to a ____________________ area of the pump.

    d. The fluid in the constricted area moves faster, causing the pressure to ____________________ so that fluid flows in behind the moving fluid.

14. Complete statements about the principles of operation of diaphragm hydraulic pumps. Write the missing word(s) on the blanks provided in the statements below.

    a. Force from an outside source, such as an engine, is applied as a ____________________ motion to a flexible diaphragm.

    b. The movement of the diaphragm causes the ____________________ of the pump chamber to alternately increase and decrease.

    c. When the pump-chamber volume ____________________, fluid flows into the pump through an inlet opening that is usually equipped with a one-way valve.

    d. When the pump-chamber volume ____________________, fluid is forced through an outlet opening that is equipped with a one-way valve.

Written Test

15. Complete statements about the principles of operation of piston hydraulic pumps. Write the missing word(s) on the blanks provided in the statements below.

    a. An outside source, such as an engine, provides force—usually rotational—that is transmitted to the ____________________.

    b. The force causes ____________________ in one or more cylinders to move back and forth.

    c. The movement of a piston causes the volume of the ____________________ to change.

    d. As the volume of the fluid side of the cylinder ____________________, fluid flows into the cylinder.

    e. The continued rotation of the ____________________ or of a mechanical device such as a spring causes the piston to move back in the cylinder.

    f. As the piston returns to ____________________ the volume on the fluid side of the cylinder, fluid is forced out of the pump.

16. List three of the typical service procedures required for hydraulic systems. Write your answers on the blanks provided.

    a. ____

    b. ____

    c. ____

17. List specialty tools used to perform hydraulic-system service. Write your answers on the blanks provided.

    a. ____

    b. ____

    c. ____

18. State the functions of the major components of pneumatic systems. Write your answers on the blanks provided beside each of the components listed below and on the next page.

    a. Reservoir ____

    ____

    b. Pump ____

    ____

Written Test

c. Actuator ____________________

d. Lines ____________________

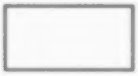
e. Cylinder ____________________

f. Piston ____________________

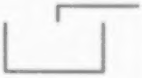
g. Valves ____________________

19. Identify common symbols used on pneumatic diagrams. Select your answers from the following list, and then write your answers on the blanks provided under each of the illustrations below. Some answers may be used more than once.

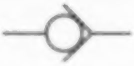
Reservoir
Pump
Piston
Check valve
Actuator
Cylinder
Shutoff valve
Motor



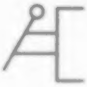
a. ____________________



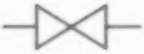
b. ____________________



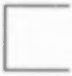
c. ____________________



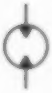
d. ____________________



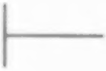
e. ____________________



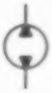
f. ____________________



g. ____________________



h. ____________________



i. ____________________

Written Test

20. State safety rules for working with pneumatic systems. Write the complete safety rule on the blanks provided beside each of the terms below.

    a. Airstreams ______________________________

    ____

    b. Removing air pressure ______________________________

    ____

    c. Working with pneumatic hoses and seals ______________________________

    ____

    d. Locating pneumatic-system leaks ______________________________

    ____

    e. Pressurized gases ______________________________

    ____

21. State guidelines for preventing equipment damage when working with pneumatic systems. Write the complete guideline on the blanks provided beside each of the terms below.

    a. Before pressurizing a pneumatic system ______________________________

    ____

    ____

    b. Contaminating pneumatic systems ______________________________

    ____

    ____

22. List types of power product equipment that use pneumatic power. Write your answers on the blanks provided.

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

    e. ______________________________

Written Test

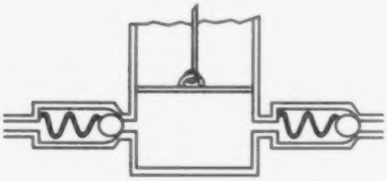
23. List applications of pneumatic systems in power product equipment. Write your answers on the blanks provided.

    a. ____

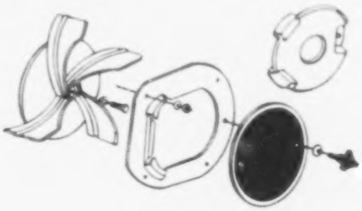
    b. ____

24. Identify types of pneumatic pumps. Select your answers from the following list, and then write your answers on the blanks provided under each of the illustrations below.

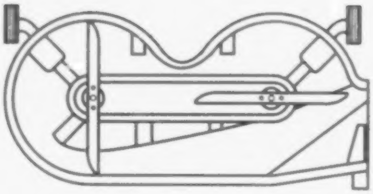
    Centrifugal
    Propeller
    Diaphragm
    Reciprocating



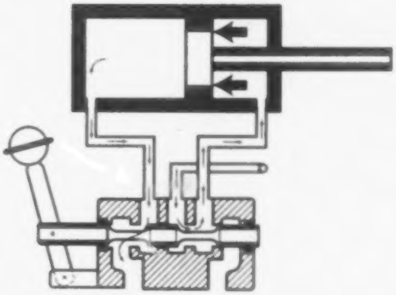
a. ______________________



b. ______________________



c. ______________________



d. ______________________

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25. State functions of the major components of pneumatic pumps. Write your answers on the blanks provided beside each of the components listed below and on the next page.

    a. Air-inlet port ____
    ____

    b. Pump body ____
    ____

c. Power input ____

____

d. Pump mechanism ____

____

e. Air-outlet port ____

____

26. Complete statements about the principles of operation of centrifugal pneumatic pumps. Write the missing word(s) on the blanks provided in the following statements.

    a. An outside source, such as an engine, provides rotational force that is transmitted to the ____________________.

    b. The rotational force causes an ____________________ within the pump to turn.

    c. ____________________ on the impeller, such as vanes, push air through the pump.

    d. The changes in pressure caused by the moving air pull additional air into the pump through an inlet near the ____________________ of the pump.

27. Complete statements about the principles of operation of propeller pneumatic pumps. Write the missing word(s) on the blanks provided in the following statements.

    a. The propeller is turned by the engine, either directly mounted on the engine-output shaft or through a ____________________ linkage.

    b. The movement of the propeller pushes air on one side of the propeller, depending on the ____________________ of the blades and the direction of rotation.

    c. As the air is pushed out of the way, a ____________________ area is created.

    d. Air from the back side of the propeller moves to the ____________________ area and air moves to replace that air.

    e. The continued rotation of the propeller repeats the cycle of moving ____________________ to create a continuous flow as long as the engine drives the propeller.

Written Test

28. Complete statements about the principles of operation of diaphragm pneumatic pumps. Write the missing word(s) on the blanks provided in the following statements.

    a. Force from an outside source, such as an engine, is applied as a ____________________ motion to a flexible diaphragm.

    b. The movement of the diaphragm causes the ____________________ of the pump chamber to alternately increase and decrease.

    c. When the pump-chamber volume ____________________, air is drawn into the pump through an inlet opening that is usually equipped with a one-way valve.

    d. When the pump-chamber volume ____________________, air is forced through an outlet opening that is equipped with a one-way valve.

29. Complete statements about the principles of operation of reciprocating pneumatic pumps. Write the missing word(s) on the blanks provided in the following statements.

    a. An outside source, such as an ____________________, provides force to move the piston in the cylinder.

    b. As the piston moves away from the valve, it creates ____________________ pressure in the cylinder.

    c. Higher-pressure air ____________________ the cylinder pushes the valve open so that air enters the cylinder.

    d. The continued operation of the engine causes the ____________________ to return in the cylinder.

    e. The movement of the ____________________ compresses the air in the cylinder, so that ____________________ increases.

    f. When the air pressure in the cylinder exceeds the outside-air pressure, the ____________________ valve closes and the ____________________ continues to compress the air until the pressure becomes great enough to open the ____________________ valve.

    g. The continued movement of the ____________________ pushes the air from the ____________________.

h. When the piston starts back in the cylinder, pressure begins to ________________, allowing the ________________ valve to close and the ________________ valve to open so that air enters the cylinder.

30. List four of the typical service procedures required for pneumatic systems. Write your answers on the blanks provided.

    a. ________________________________

    b. ________________________________

    c. ________________________________

    d. ________________________________

31. List specialty tools used to perform pneumatic-system service. Write your answers on the blanks provided.

    a. ________________________________

    b. ________________________________

Permission to duplicate this test is granted.

Principles of Fluid Power
Unit 3

Unit Evaluation Form

Student name ______________________________ Unit rating ______________

Assignment-sheet rating

Assignment Sheet 1—Interpret Flow Diagrams and Assembly Drawings Rating ______

Comments: ____

____

Job-sheet ratings

Job Sheet 1—Measure Hydraulic-System Temperature Rating ______

Comments: ____

____

Job Sheet 2—Measure Hydraulic-System Pressure Rating ______

Comments: ____

____

Job Sheet 3—Measure Hydraulic-System Flow Rating ______

Comments: ____

____

Job Sheet 4—Measure Air Pressure Rating ______

Comments: ____

____

Job Sheet 5—Measure Airflow Rating ______

Comments: ____

____

Unit Evaluation Form

Written-test scores

Pretest ________ Posttest ________ Other ________

Comments: ____

____

Teacher signature ________________________ Date ____________

Student signature ________________________ Date ____________

Permission to duplicate this form is granted.

Principles of Fluid Power
Unit 3

Teacher Supplement 1—Student Handout—Basics of Hydraulics

Note to instructor

The student handout that follows is included to help your students develop a better understanding of hydraulics. This may be necessary because their backgrounds have not adequately acquainted them with the concepts of fluid power, because you want to take your students beyond the material provided in this unit's information sheet, or because an individual student may require extra reinforcement in this area or shows special interest in this topic.

The handout covers the design of hydraulic systems and the components commonly used in power product equipment. It also covers the multiplication of force and the effects of differences in piston areas on rate of flow and stroke length of pistons.

Use the information in this handout and in other resources to teach hydraulics as the topic applies to power product equipment. You may use the information as a teaching aid, or copy it for distribution to the students. If distributed to students, the material can serve as a reference to support your presentation or as a self-study guide for independent learning. Modify the handout as necessary to tailor it to the specific material that you want to present.

Principles of Fluid Power
Unit 3

Student Handout—Basics of Hydraulics

Introduction

There are many applications for hydraulics in power product equipment—brake and steering systems, hydrostatic transmissions, lift systems, hydraulic PTOs, etc. In order to properly service these systems, you must have a basic understanding of fluid-power concepts and design principles. This supplement will acquaint you with some of the more important facts about hydraulics. Let's begin by examining the hydraulic-system components most commonly used with power product equipment.

Hydraulic-system components

Reservoirs

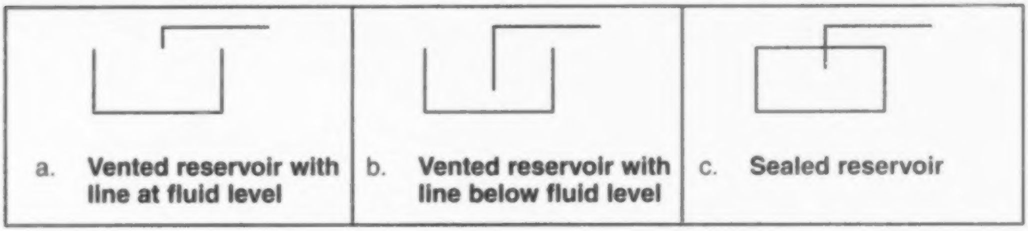
Two basic types of hydraulic systems are used in power product equipment: displacement and circulating. The difference between these two types of systems is whether fluid simply shifts through the system when displaced by an actuator (as with a brake system) or whether the fluid actually circulates through the system (as with a hydrostatic transmission). In both cases, fluid is stored in the system. Fluid is present in lines, cylinders, valves, and other components, but the primary purpose of the reservoir is to store fluid that is not actively in use by the system. In some cases, fluid is simply contained in a cylinder; in other cases, the fluid is stored in a separate component designed specifically for that purpose.

In a typical displacement system—such as a hydraulic brake system—the operator pushes a pedal that moves a piston to move fluid from the master cylinder (reservoir) into the brake lines. This action causes pistons in the wheel cylinders to move, exerting pressure against the wheels to slow or stop the vehicle. When the pedal is released, springs or other mechanical devices force the pistons in the wheel cylinders back, causing the excess fluid to return to the master cylinder. In this design, the transmission of force is accomplished through the simple shifting of fluid through the system.

In a typical circulating system, fluid actually moves from the reservoir, completely through the active part of the system, and back to the reservoir.

The common symbols for reservoirs are shown in Figure 1 on the next page. The box portion of the symbol represents the reservoir, while the line above or connected to the box represents a line connected to the reservoir. Often a reservoir will have more than one line connected to it, having at least one inlet and one outlet. Some reservoirs are sealed, as represented by the four-sided box (see Figure 1-c). Reservoirs may be vented to outside air as indicated by the three-sided boxes in Figures 1-a and 1-b. The lines that connect to the reservoir may connect to the top, bottom, or sides, and their positioning at fluid level or below fluid level is sometimes indicated in the diagrams, as in Figures 1-a and 1-b.

Figure 1: Reservoir symbols



a. **Vented reservoir with line at fluid level**

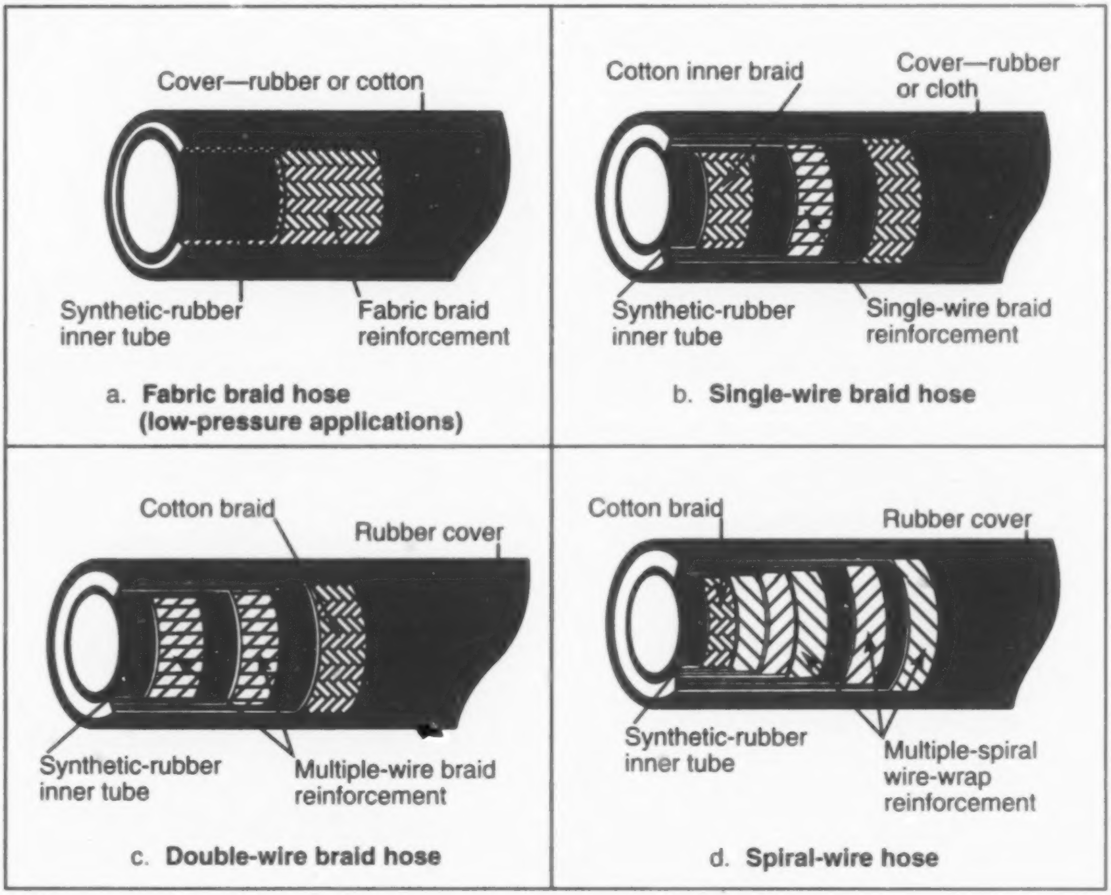
b. **Vented reservoir with line below fluid level**

c. **Sealed reservoir**

Lines/hoses

Components in a hydraulic system are connected by lines and hoses. Lines are generally made of steel or aluminum; hoses are usually made of wire fabric and braid. Figure 2 shows the construction of hoses commonly used in hydraulic systems.

Figure 2: Types of hoses


Cover—rubber or cotton
Synthetic-rubber inner tube
Fabric braid reinforcement
Cotton inner braid
Cover—rubber or cloth
Synthetic-rubber inner tube
Single-wire braid reinforcement
Cotton braid
Rubber cover
Synthetic-rubber inner tube
Multiple-wire braid reinforcement
Cotton braid
Rubber cover
Synthetic-rubber inner tube
Multiple-spiral wire-wrap reinforcement

a. **Fabric braid hose (low-pressure applications)**

b. **Single-wire braid hose**

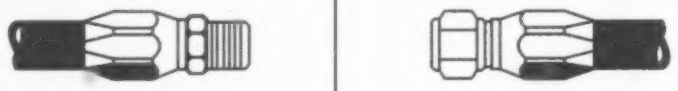
c. **Double-wire braid hose**

d. **Spiral-wire hose**

Fittings

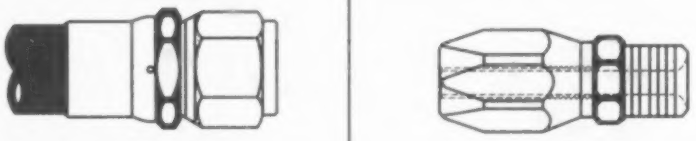
Both hoses and lines use fittings to connect to hydraulic components. These fittings are generally steel or brass and are usually threaded. A sampling of these fittings is shown in Figure 3. Often, hoses and lines are constructed for specific applications and are made to required lengths with the proper fittings installed. However, most fittings are also available so that a technician can build hoses and lines for specific applications. Connections can be installed on lines with flares or by methods that are similar to those used on fuel lines and other applications. Hose fittings may be pressed or clamped into place.

Figure 3: Common types of fittings



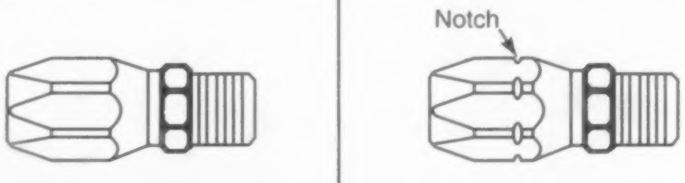
a. **Male coupler**

b. **Female coupler**



c. **Permanent fitting**

d. **Reusable fitting**

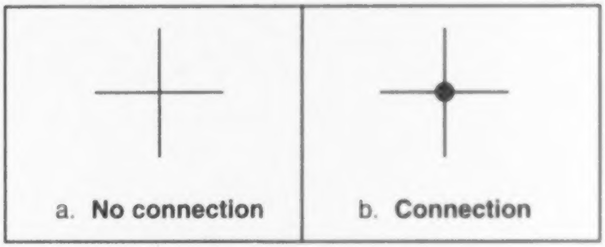


e. **Medium-pressure fitting**

f. **High-pressure fitting (notched fitting)**

Symbols for lines and hoses may be as simple as a solid black line or a pair of lines. When a pair of lines is used, color coding or patterns may be used to show the routing or pressurization of a line. When a single line is used, two different conventions may be found similar to that seen in electrical circuits. Figures 4 and 5 on the next page illustrate these two conventions for hydraulic lines that cross each other with or without connections.

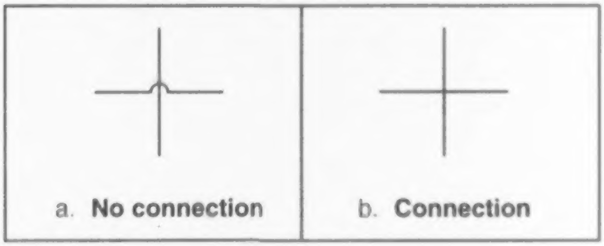
Figure 4: Convention 1



a. **No connection**

b. **Connection**

Figure 5: Convention 2



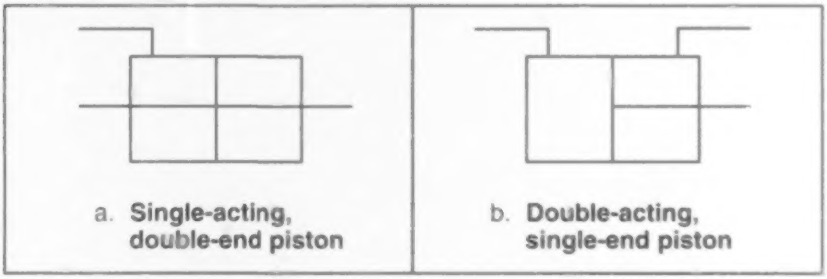
a. **No connection**

b. **Connection**

Cylinders

There are great variations in the designs of pistons and cylinders. One factor that determines these design variations is the need to multiply or reduce pressure. These concepts are further explained near the end of this handout. A second factor that influences cylinder design is the level of action on a piston. A piston may be single acting or double acting. A single-acting piston is acted upon by pressurized fluid on one side, while a double-acting piston is acted upon from both sides. Similarly, a piston may be constructed with a single-end rod or a double-end rod. Figure 6 shows the symbol for a single-acting, double-end piston and for a double-acting, single-end piston.

Figure 6: Cylinder symbols



a. **Single-acting, double-end piston**

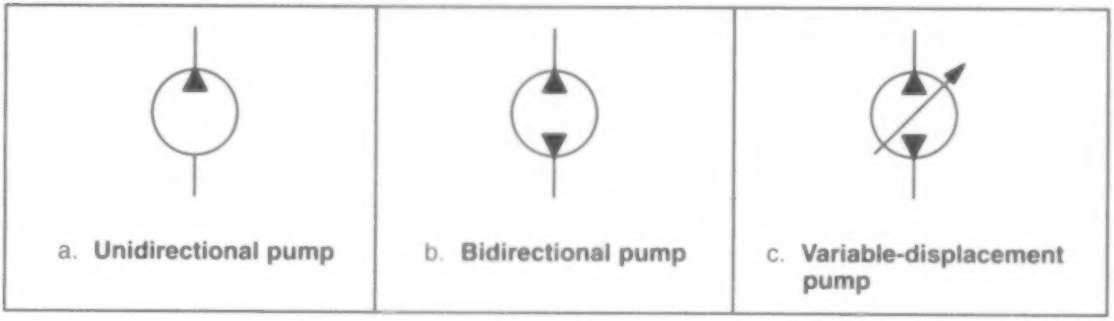
b. **Double-acting, single-end piston**

Pumps

Pumps are primarily used for circulating hydraulic systems. Even so, there are numerous designs of such pumps. Technicians are not generally involved in the selection of pumps used as original equipment, but technicians must be able to recognize the type of pump used on a system and understand its operation in order to troubleshoot and repair hydraulic-system problems.

Three major design factors are of principal concern. The first factor is the type of pump, as discussed in the information sheet. The second factor is displacement. *Displacement* is "the volume of fluid moved through the pump with each cycle." Displacement can be fixed, meaning that the volume is the same with each cycle, or variable, meaning that the volume can be varied from one cycle to another. The third factor is direction. A pump may move fluid in one direction only or in one of two directions. Symbols for hydraulic pumps are shown in Figure 7.

Figure 7: Pump symbols



a. **Unidirectional pump**

b. **Bidirectional pump**

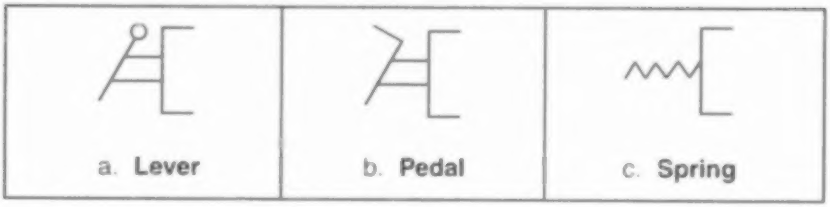
c. **Variable-displacement pump**

Actuators

A hydraulic system is not very useful if it is not equipped with a means for allowing the operator to control the system. Numerous methods are used for actuating hydraulic systems. For a circulating system, the actuator may be a switch that turns on the engine or other power source, or the actuator may be a clutch-like device that engages the hydraulic pump. In a displacement system, hand levers and foot pedals are commonly used on power product equipment. Hand levers are used with many lift systems, and steering wheels are actuators in power-steering systems. Multiple-speed hydrostatic transmissions generally use levers for setting speeds. Most hydraulic-brake systems and some lift systems use foot pedals.

Some hydraulic systems or functions within hydraulic systems are actuated automatically. These functions are normally controlled with springs or with pressure through the positioning of control valves. The symbols for levers, pedals, and springs are shown in the illustrations in Figure 8 on the next page.

Figure 8: Actuator symbols



a. **Lever** b. **Pedal** c. **Spring**

Valves

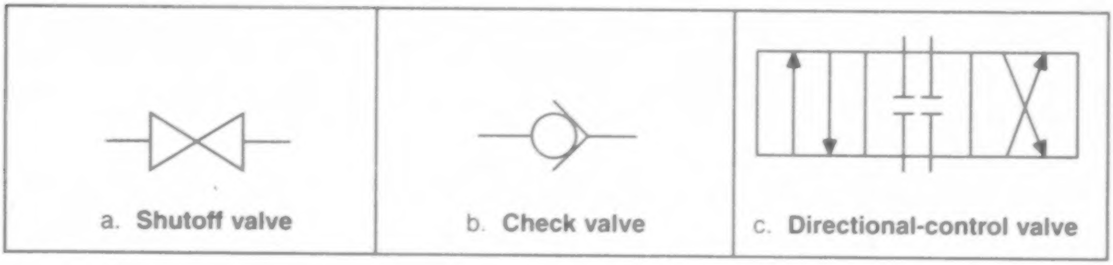
Valves are designed to control various aspects of flow. First, some types of valves control whether flow occurs at all. For example, a shutoff valve (see Figure 9-a) is used to open or completely close a hydraulic line. Shutoff valves may be manual or automatic.

Second, some types of shutoff valves open only partially to create a restriction in a hydraulic line. A restriction has several effects on a hydraulic system. Because the rate of flow is constant through a given section of the system, fluid must flow faster through the restricted area. The faster-flowing fluid will have the same level of energy (disregarding friction), which means that the pressure is less in the restricted area. Thus, a valve can be used to regulate the pressure in a section of hydraulic line.

Third, some types of valves regulate pressure because they are pressure sensitive. The most common uses of pressure-sensitive valves are relief valves and check valves. Relief valves are designed to prevent pressure from building beyond a desired level. Check valves (see Figure 9-b) are designed to prevent flow until pressure reaches a prescribed level. Check valves can be one-way or two-way. A one-way check valve allows fluid flow in one direction only. A two-way check valve allows flow in the direction of greater pressure.

Fourth, hydraulic systems can also include very complicated valves that provide directional control. For example, the valve shown in Figure 9-c shows a three-way directional-control valve. The left section allows straight-through flow of the two lines. The center section shuts off both lines. The right section reroutes the flow between the lines. Many other combinations are possible, such as having one line shut off and one allowed to flow, the use of more than two lines, etc.

Figure 9: Valve symbols

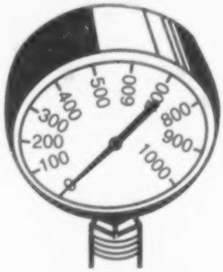


a. **Shutoff valve** b. **Check valve** c. **Directional-control valve**

Instruments

The two most common instruments used in hydraulic systems are pressure gauges and thermometers. These instruments are illustrated in Figure 10 below. Thermometers are only found on very specialized equipment, but certain types of power product equipment with lift capabilities sometimes provide pressure gauges.

Figure 10: Hydraulic instruments



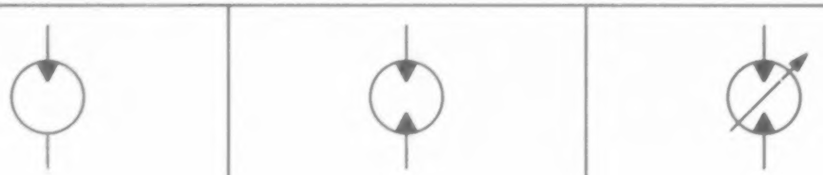
a. **Pressure gauge**

b. **Thermometer**

Hydraulic motors

Many types of power product equipment use hydraulic pumps to drive hydraulic motors, which in turn power the drive axle. Other types of equipment use hydraulic motors for PTOs. A hydraulic motor is essentially like a pump, except that in a pump a mechanical input causes the pump to operate to create a flow of fluid in the hydraulic system. A hydraulic motor is driven by the flow of hydraulic fluid and produces a mechanical output. Symbols for motors (see Figure 11) differ from symbols for pumps (see Figure 7 on page 145) by having an arrowhead that points in to indicate the direction of hydraulic-fluid flow. Motors can be unidirectional or bidirectional and can have fixed or variable displacement (see Figure 11).

Figure 11: Motor symbols



a. **Unidirectional motor**

b. **Bidirectional motor**

c. **Variable-displacement motor**

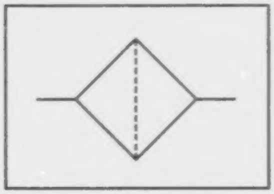
Fluid and fluid-conditioning components

As fluid circulates through a hydraulic system, it can lose its effectiveness. The three most common reasons for a loss of hydraulic-fluid effectiveness are turbulence, contamination, and heat.

Turbulence. There is little that the technician can do about turbulence, which is usually a design problem caused by excessive bends and restrictions, though worn pumps and valves and defective lines can contribute to turbulence.

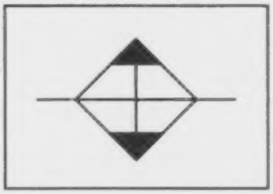
Contaminants. Common contaminants in hydraulic fluids include dirt, grit, oil, water, and air. Air is sometimes introduced into a system through worn pumps and loose fittings. To reduce contaminants, some hydraulic systems include filters. Power product equipment systems generally use wire-mesh, paper, or cloth filters. The symbol in Figure 12 is used to represent hydraulic filters.

Figure 12: Hydraulic-filter symbol



Heat. The movement of hydraulic fluid through a system leads to a buildup of heat. Heat is harmful not only to the system components but also to system efficiency because heat reduces the viscosity of the hydraulic fluid, can affect flow rates, etc. Many hydraulic systems provide for cooling of the fluid within the system. Cooling systems may be as simple as routing lines and hoses so that they will be exposed to circulating air, or the cooling system may be a specific portion of the hydraulic system with a separate radiator. Cooling systems are represented as shown by the symbol in Figure 13.

Figure 13: Hydraulic cooling-system symbol



Basic hydraulic principles

The purpose of hydraulic systems—just like their electrical and mechanical counterparts—is to transmit energy from one place to another. This energy transmission is possible because of some of the basic characteristics of liquids. These characteristics include those in the following statements.

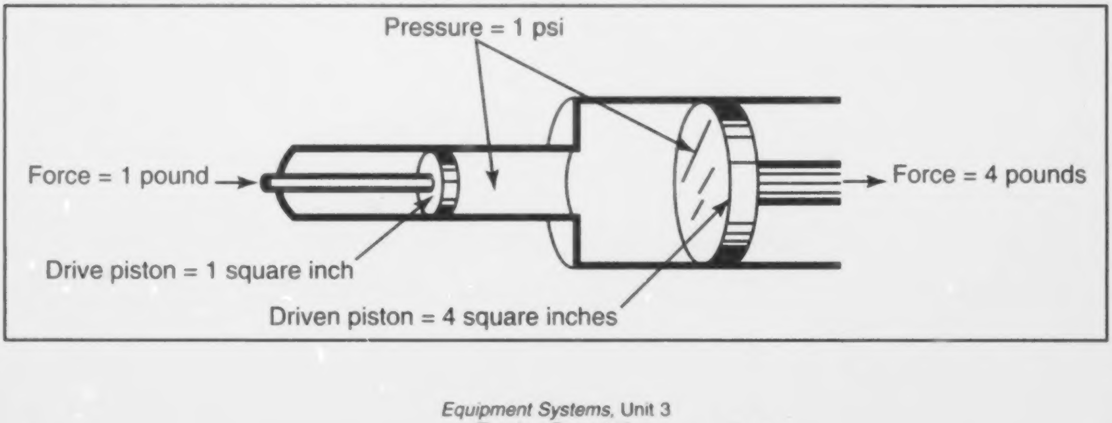
- Liquids have no shape of their own. They will conform to the shapes of cylinders, reservoirs, lines, valves, and other components.
- Liquids will not compress. If pressure is applied to a liquid, the force of that pressure will be transmitted through the liquid. If the liquid is confined as in a hydraulic system, that force will be transmitted equally in all directions, making the liquid like a mechanical linkage, except that the force can be transmitted around bends without elaborate connections.
- By regulating the container around the liquid, force can be increased or reduced.

The work of a hydraulic system is accomplished through the movement of fluid, which in turn moves pistons, valves, pump vanes or gears, etc., to provide mechanical output. There are four characteristics of movement. First, there is direction. The direction of movement is controlled by the design of the system, such as the routing of lines, the positioning of valves, the way a cylinder allows piston movement, and other design features. Second, there is distance. Movement takes place over a given distance within the system. Third, there is speed—how long it takes to travel the prescribed distance. Speed is normally stated as a unit of distance per a unit of time, such as miles per hour or feet per second or millimeters per minute. Fourth, the movement of an object requires and produces force. For every movement, there is an input force and there is an output force. For example, it may take 40 pounds of force to move a 300-pound garden tractor on a level surface. To keep the tractor moving or to stop it will take additional force. To make it go faster will also take additional force. In fact, the force of a moving object is normally stated as a product of its weight (mass) and its speed.

Force at work

These basic hydraulic principles apply whether the moving object is a garden tractor, the wind, or a piston in a hydraulic system. Let's see how they work in a hydraulic system by examining the reactions of pistons when force is applied to them. The drawing in Figure 14 shows a hydraulic cylinder. The left side of the cylinder has a piston with a 1-square-inch surface area, while the right side of the cylinder has a piston with a 4-square-inch surface area. The space between the two pistons is filled with hydraulic fluid.

Figure 14: Force in a hydraulic system

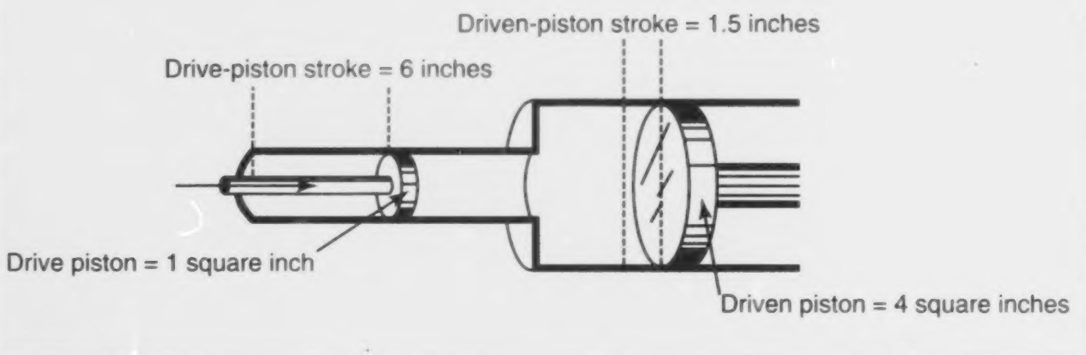


Assume that 1 pound of force is applied to the smaller piston, causing it to travel at a rate of 2 inches per minute along its 6-inch stroke. This force results in the piston becoming the drive piston. Because the area of the drive piston is 1 square inch, the output force of the piston's movement is 1 pound per square inch. The drive piston pushes the fluid between the pistons, which transmits the 1-psi force equally in all directions. As a result, 1 pound of force is applied to each square inch of the larger piston—the driven piston. Consequently, the output of the driven piston is 4 pounds. The formula for computing the force in a piston system as applicable to this example is

Force = Pressure x Area of piston
= 1 psi x 4 square inches
= 4 pounds

At first it may appear that the system has produced force out of nothing. However, you probably realize from your studies of engines and other subjects that this additional force cannot be produced without some loss somewhere else. To find out how the force was increased, we have to look at some of the other characteristics of motion discussed previously. For example, we discussed that distance was one characteristic of movement, and in our example, the drive piston has a stroke of 6 inches. Does that mean that the second piston will move 6 inches? The answer is no. Actually, the ratio of the strokes of the two will be the inverse of the ratio of their surface areas. Going back to our example, because the driven piston has a surface area four times greater than that of the drive piston, its stroke will be one-fourth that of the drive piston.

Figure 15: Stroke in a hydraulic system


Driven-piston stroke = 1.5 inches
Drive-piston stroke = 6 inches
Drive piston = 1 square inch
Driven piston = 4 square inches

In the example, the ratio between the areas of the two pistons is

Ratio of surface areas = 1 : 4

Thus, the ratio of the strokes would be the inverse of the ratio of their areas, leading to the following ratio in our example:

Ratio of strokes = 4 : 1

To solve for distance that the driven piston moves, divide the stroke length of the drive piston by 4. The equation would be

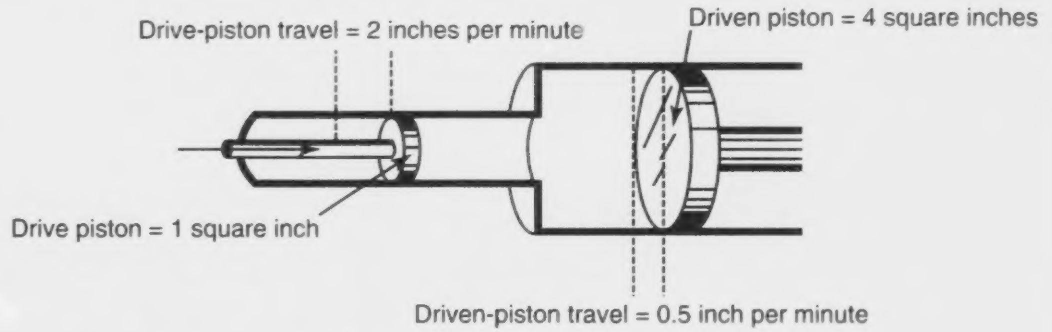
Driven-piston stroke = Drive-piston stroke ÷ Ratio of areas
= 6 ÷ 4
= 1.5 inches

The reason for these relationships is that the volume of hydraulic fluid moved by the drive piston is a specific amount. In our example, this volume is equal to 6 cubic inches. That is, the volume of a cylinder 6 inches long with an area of 1 square inch is 6 cubic inches, or 6 inches x 1 square inch = 6 cubic inches. Thus, 6 cubic inches of fluid will be displaced. That will result in the driven piston moving in its cylinder 1.5 inches, or

1.5 inches x 4 square inches = 6 cubic inches.

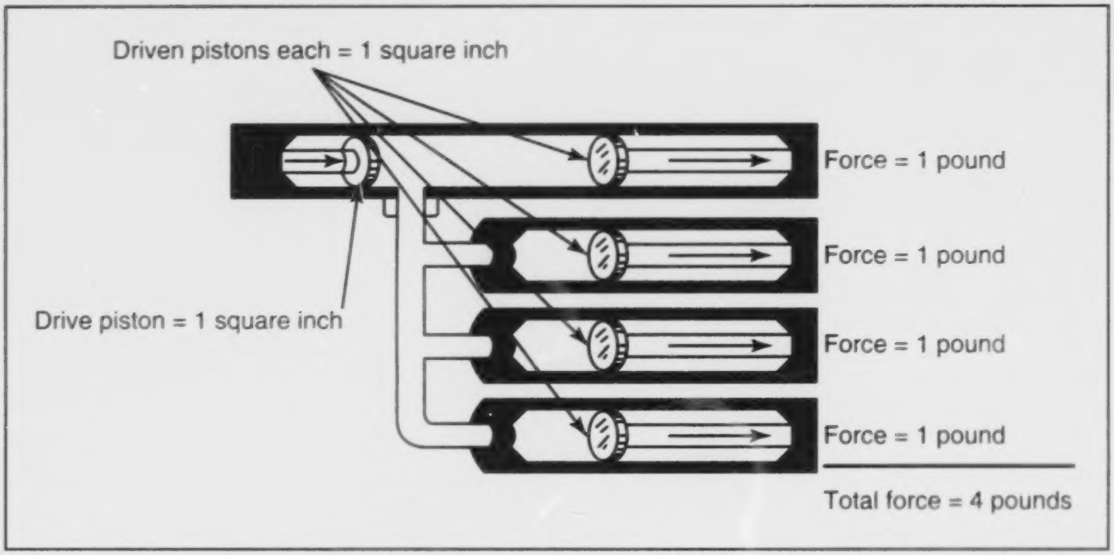
In a similar way, the speed of the larger piston will be slower than that of the smaller piston. Again, the ratio of the two speeds will be the inverse of their areas. Assume that the drive piston in our example moves at a rate of 2 inches per minute. Thus, it will take 3 minutes for the drive piston to travel its full stroke length of 6 inches. This is the amount of time required to displace 6 cubic inches of fluid. But, as shown in the previous calculation, the driven piston will travel only 1.5 inches when 6 cubic inches of fluid are displaced. It will take the same 3 minutes for the driven piston to travel 1.5 inches. Therefore, it is traveling at a speed of 0.5 inch per minute. This is one-fourth of the rate of the drive piston's 2 inches per minute, which is also the inverse of the ratio of the areas of the two pistons.

Figure 16: Rate of flow in a hydraulic system


Drive-piston travel = 2 inches per minute
Driven piston = 4 square inches
Drive piston = 1 square inch
Driven-piston travel = 0.5 inch per minute

These same principles apply in multiple-cylinder systems. For example, in Figure 17 on the next page, a drive piston with a surface area of 1 square inch to which 1 pound of force is applied will move all four driven pistons with the same effects as if acting upon a single piston with an area of 4 square inches. Each driven piston will produce a 1-pound force for a total of 4 pounds of output, but the distance traveled and the rate of travel will be one-fourth as much in the driven pistons as for the drive piston.

Figure 17: Multiple-cylinder system

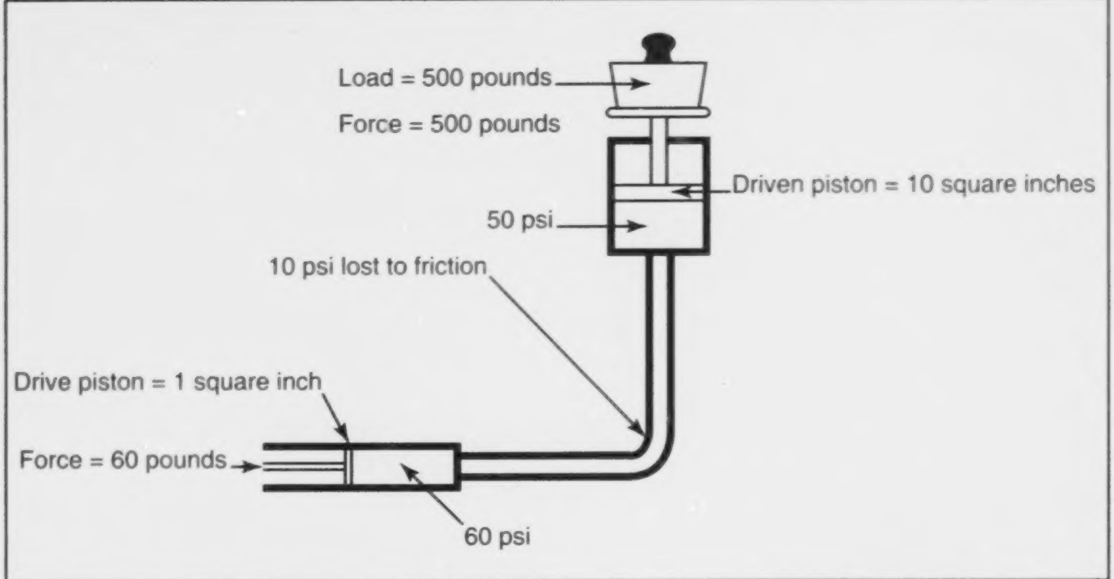


Practical applications

The information presented in the previous section is a summary of basic hydraulic principles and should give you a good overview of the fundamental relationships in hydraulic circuits as used in power product equipment. This is probably a detailed enough level for your training as a power product equipment technician. However, there are a few more concepts that you need to understand so that you will recognize their effects in hydraulic-circuit applications that you are likely to encounter.

The first is that the transmission of force through a hydraulic system is not perfect. As you know, when two objects in contact with each other move, friction is generated. This is true of hydraulic fluid moving through a system. Friction results from the movement of the fluid along the lines and from the movement of pistons, motors, pressure valves, and other components. Some of the input force is required to overcome friction. Thus, not all of the force applied to the drive piston will be transmitted through the system. Figure 18 on the next page provides an example. Sixty pounds of force are applied to a piston with a surface area of 1 square inch and transmitted to a driven piston with an area of 10 square inches. Theoretically, the output would be 600 pounds (60 psi x 10 square inches), but if an allowance is made for friction, the output will be less. Assume, for example, that 10 psi are lost to friction by the time the force reaches the driven piston. In this case, the output would only be 500 pounds (50 psi x 10 square inches).

Figure 18: Force lost to friction



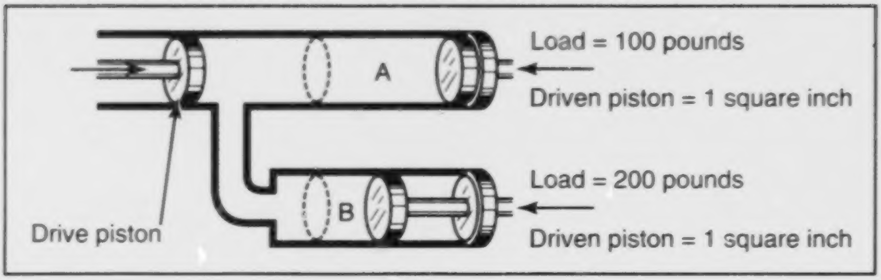
Force = 60 psi – 10 psi x 10 square inches = 500 pounds

As a power product equipment technician, you will not be required to calculate the loss of force due to friction, but you do need to understand the concept so that you will recognize that power transmission is not perfect and so that you will realize that the movement of fluid through a hydraulic system leads to friction, which you know produces heat. In some hydraulic systems, the heat produced is significant enough that cooling systems are used.

A second reality of hydraulic systems is that the outputs are hooked up to mechanical loads. After all, that is the purpose of having a hydraulic system. Consequently, before there is any movement in a driven piston, the force generated must overcome the load. In Figure 18, for example, if friction had reduced the pressure by 15 psi so that only 45 psi were applied to the drive piston, then the load would not have moved because the available force of 450 pounds is not enough to lift the 500-pound load.

These factors come into play in multiple-cylinder systems also. For example, Figure 19 on the next page shows a multiple-cylinder system in which all the pistons are the same size. However, the driven piston labeled “A” has a 100-pound load, while the driven piston labeled “B” has a 200-pound load.

Figure 19: Equal-size, multiple-cylinder system


Load = 100 pounds
Driven piston = 1 square inch
A
Load = 200 pounds
B
Drive piston
Driven piston = 1 square inch

Consider the following situations and the movement of the pistons in each:

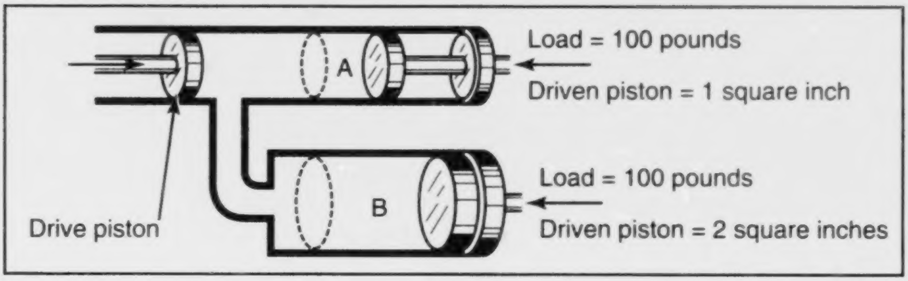
- What if 50 pounds of force are applied to the drive piston? Neither driven piston will move.
- What if 110 pounds of force are applied to the drive piston? Piston A will move, but Piston B will not.
- What if 200 pounds of force are applied to the drive piston? Both pistons will move, but Piston A will take half as much time to complete its travel.

These principles are important because numerous hydraulic applications in power product equipment take advantage of them. In this way, force can be selectively applied to different parts of a system, causing some parts to operate and others to remain inoperative at low pressures.

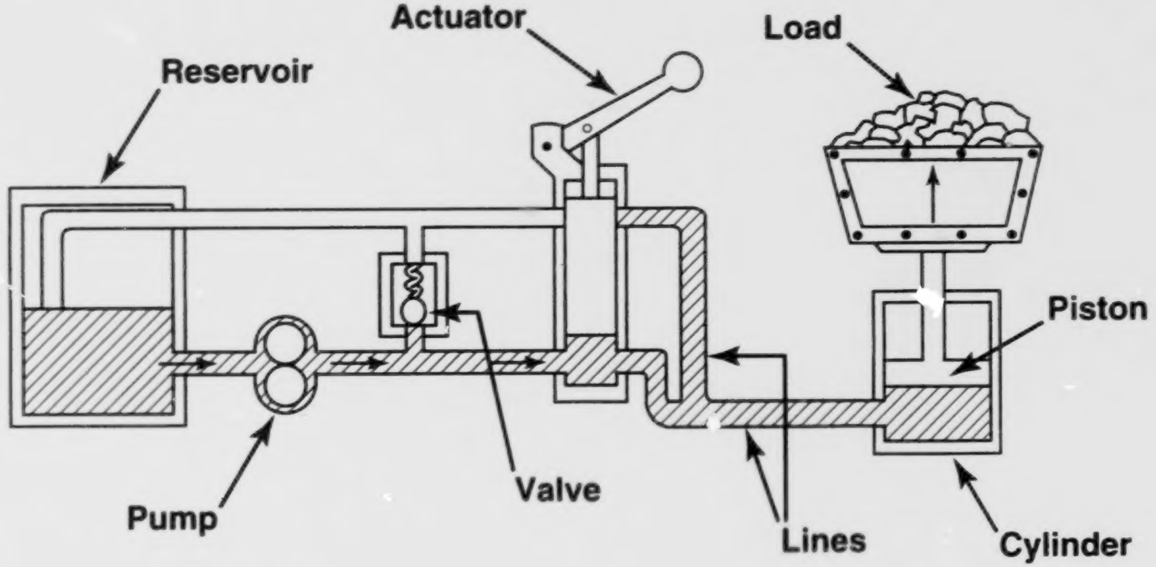
Figure 20 shows another application of these principles. In this case, both driven pistons have the same load, but one driven piston is larger than the other. Disregarding friction, if 50 pounds of force are applied to the drive piston, Piston B will move because that 50 pounds of force become 100 pounds against Piston B. If 100 pounds of force are applied, both pistons will move, but Piston B will complete its travel sooner because more effective force is being applied to the same amount of load.

These principles should help you understand the operation of the hydraulic systems that you are likely to encounter when working with power product equipment.

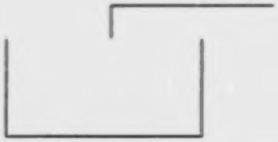
Figure 20: Unequal-size, multiple-cylinder system


Load = 100 pounds
A
Driven piston = 1 square inch
Load = 100 pounds
B
Drive piston
Driven piston = 2 square inches

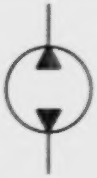
Major Components of Hydraulic Systems


Actuator
Load
Reservoir
Piston
Valve
Pump
Lines
Cylinder

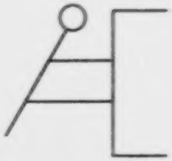
Common Symbols Used on Hydraulic Diagrams



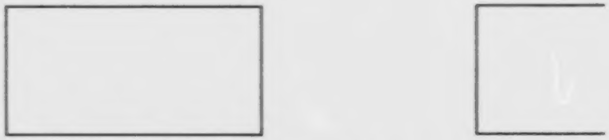
Reservoir



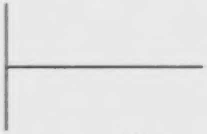
Pump



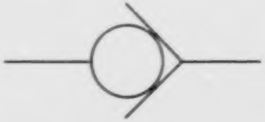
Actuator



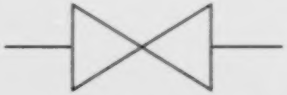
Cylinders



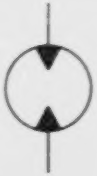
Piston



Check valve

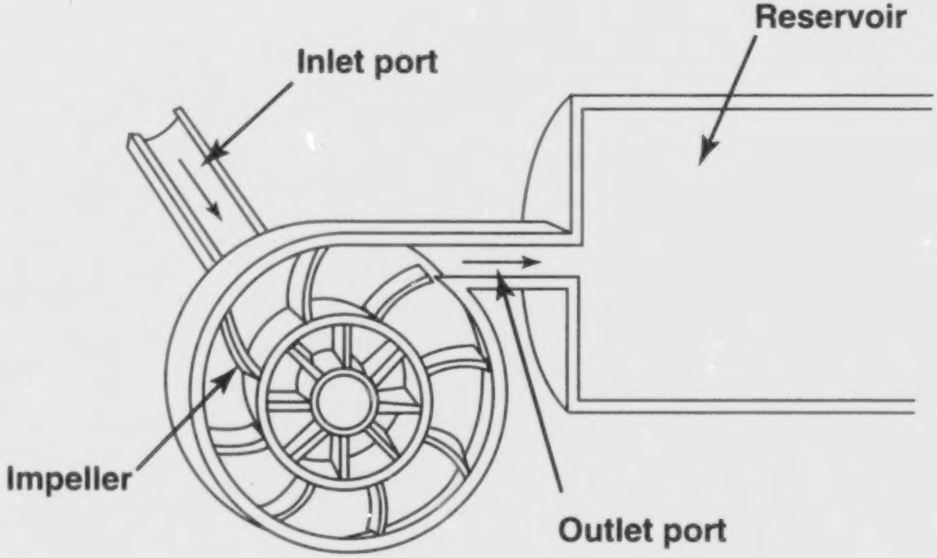


Shutoff valve

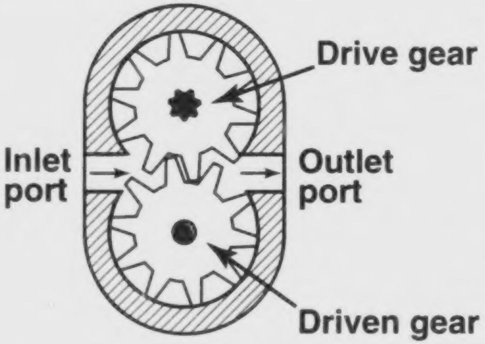


Motor

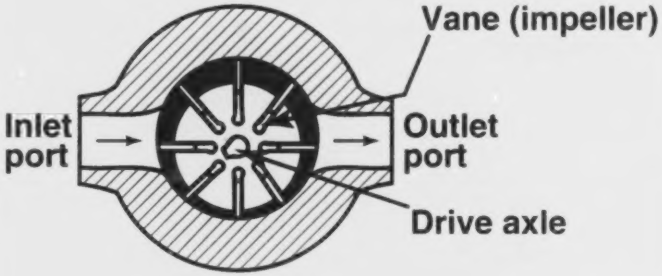
Types of Hydraulic Pumps: Centrifugal


Reservoir
Inlet port
Impeller
Outlet port

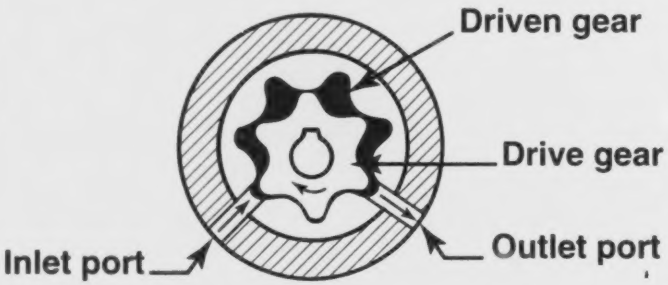
Types of Hydraulic Pumps: Rotary


Drive gear
Inlet port
Outlet port
Driven gear

Rotary/gear


Vane (impeller)
Inlet port
Outlet port
Drive axle

Rotary/vane

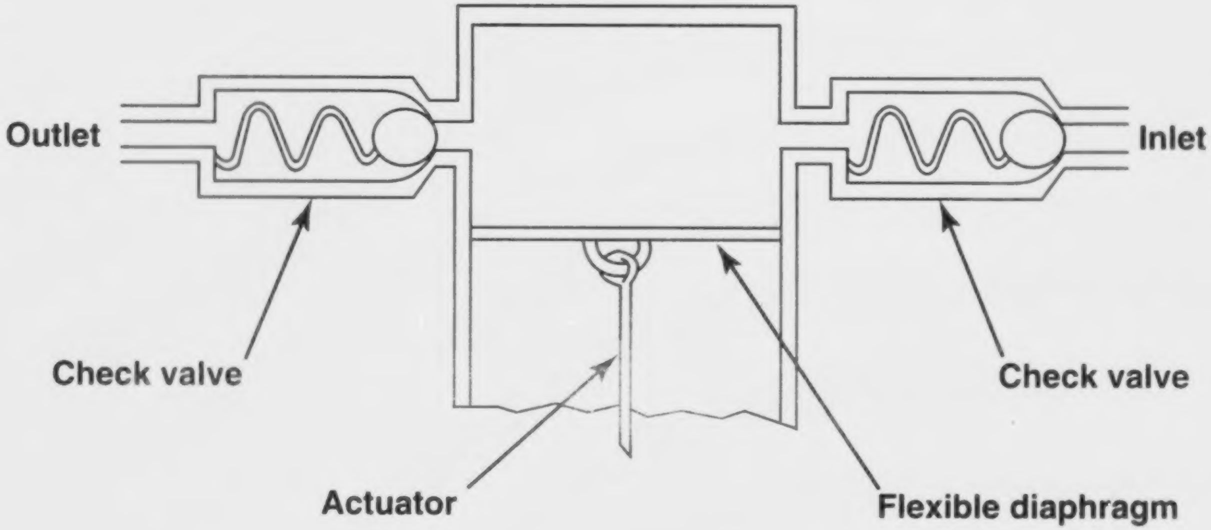

Driven gear
Drive gear
Inlet port
Outlet port

Rotary/gerotor

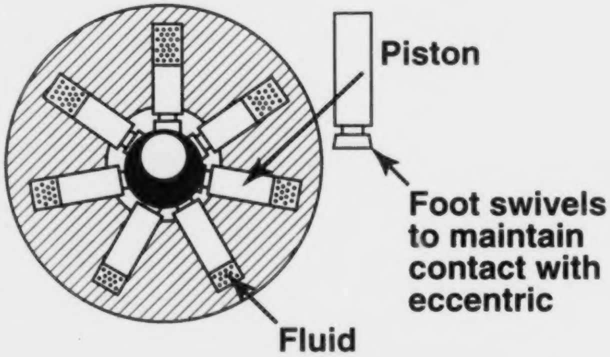
Equipment Systems, Unit 3
Teacher Page 161

TM 4

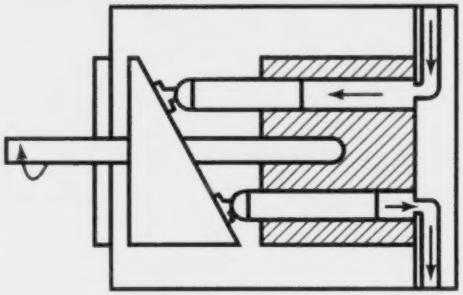
Types of Hydraulic Pumps: Diaphragm


Outlet
Inlet
Check valve
Check valve
Actuator
Flexible diaphragm

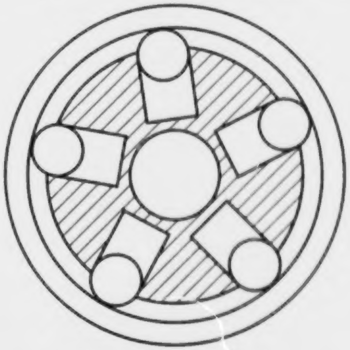
Types of Hydraulic Pumps: Piston


Piston
Foot swivels to maintain contact with eccentric
Fluid

Piston/radial



Piston/axial

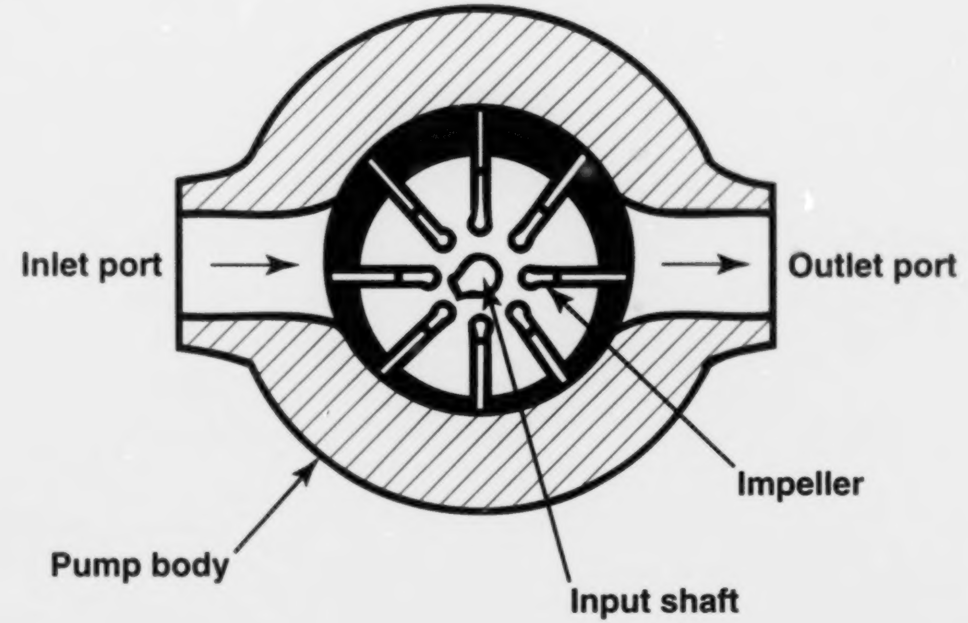


Piston/ball

Equipment Systems, Unit 3
Teacher Page 165

TM 6

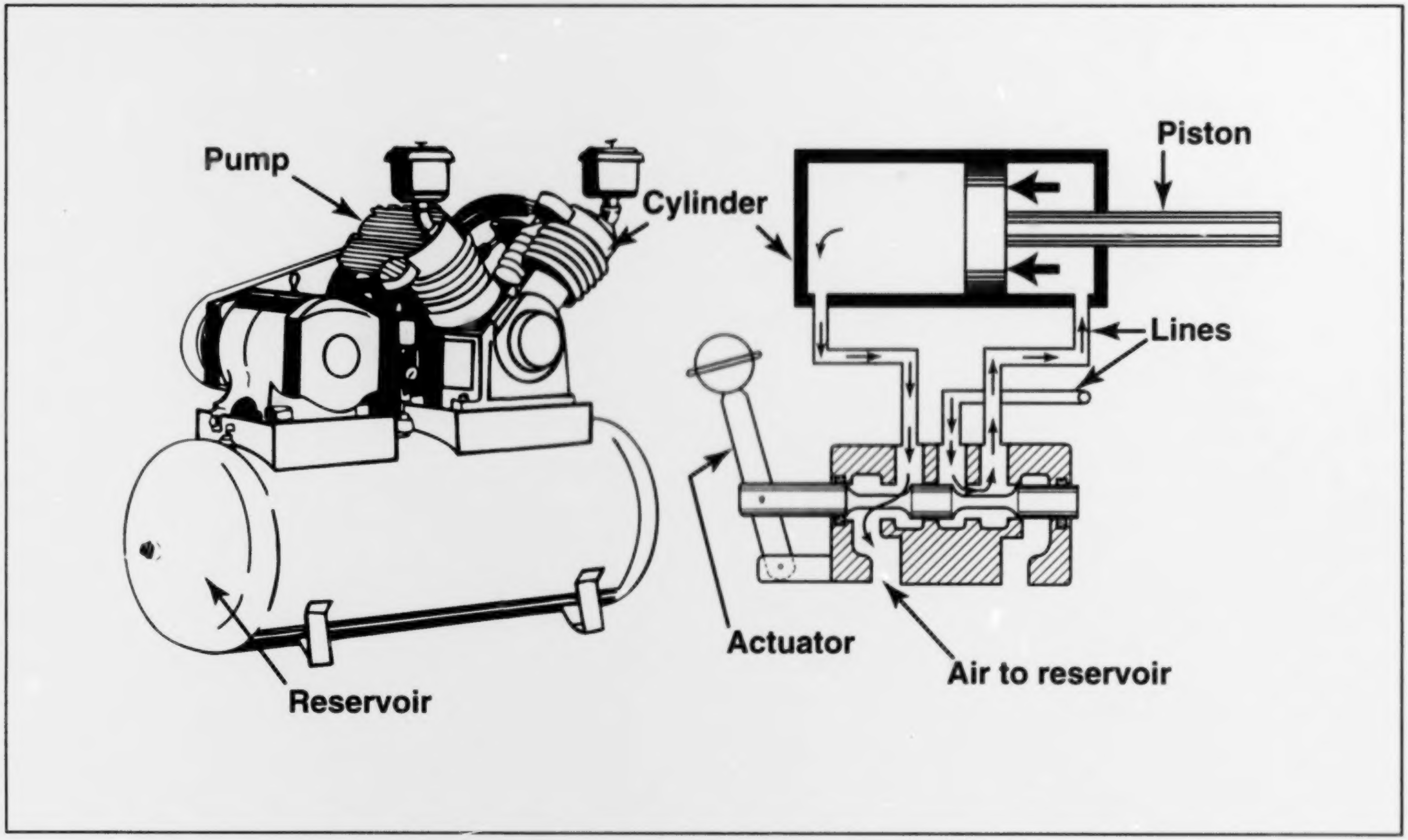
Major Components of Hydraulic Pumps


Inlet port
Outlet port
Impeller
Pump body
Input shaft

Equipment Systems, Unit 3
Teacher Page 167

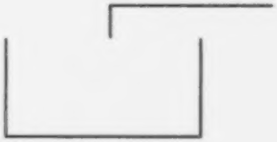
TM 7

Major Components of Pneumatic Systems

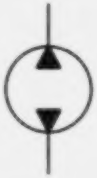

Pump
Cylinder
Piston
Lines
Actuator
Air to reservoir
Reservoir

Drawings reproduced by permission of the publisher, Womack Educational Publications, from *Industrial Fluid Power,* Volume 1, 3rd ed., prepared by Charles S. Hedges, copyright 1997.

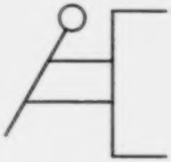
Common Symbols Used on Pneumatic Diagrams



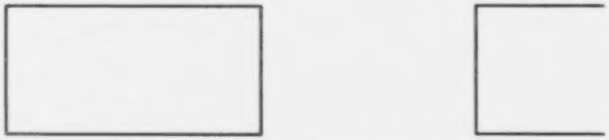
Reservoir



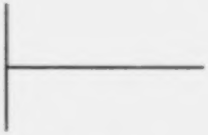
Pump



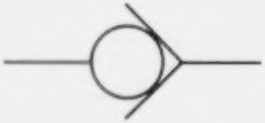
Actuator



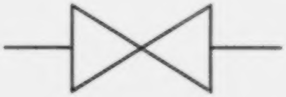
Cylinders



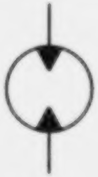
Piston



Check valve



Shutoff valve



Motor

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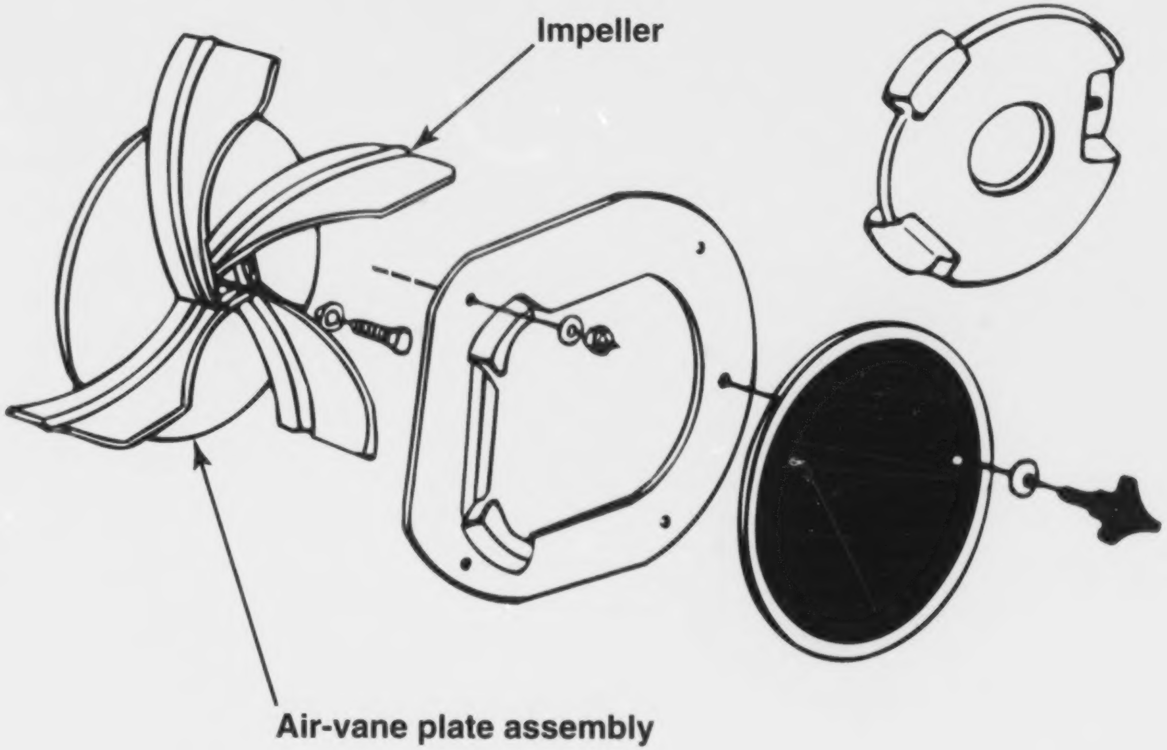
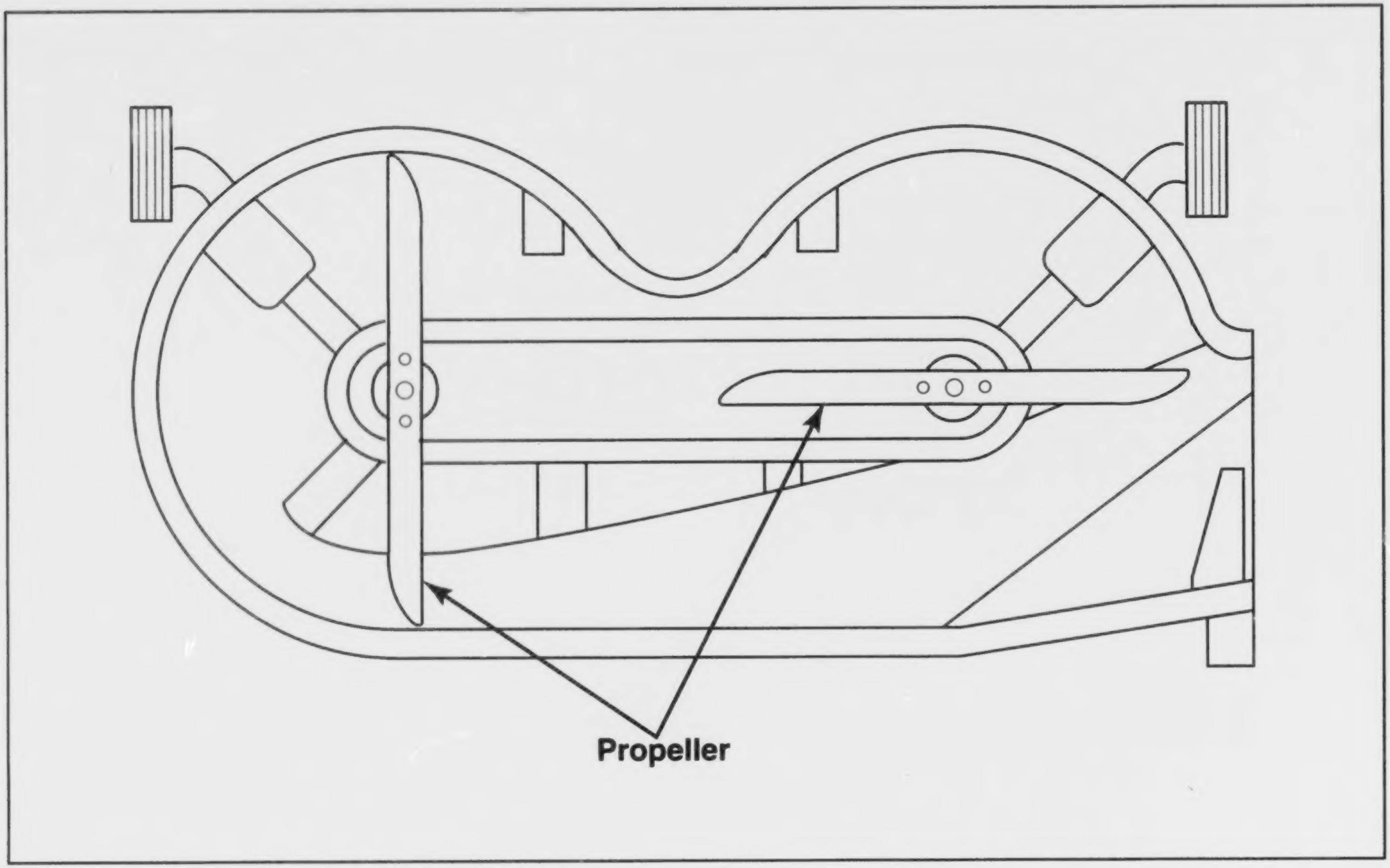
Types of Pneumatic Pumps: Centrifugal


Impeller
Air-vane plate assembly

Drawing reproduced by permission of Mike Barnett, MTD Products, Inc., Cleveland, Ohio.

Types of Pneumatic Pumps: Propeller



Drawing reproduced by permission of Mike Barnett, MTD Products, Inc., Cleveland, Ohio.

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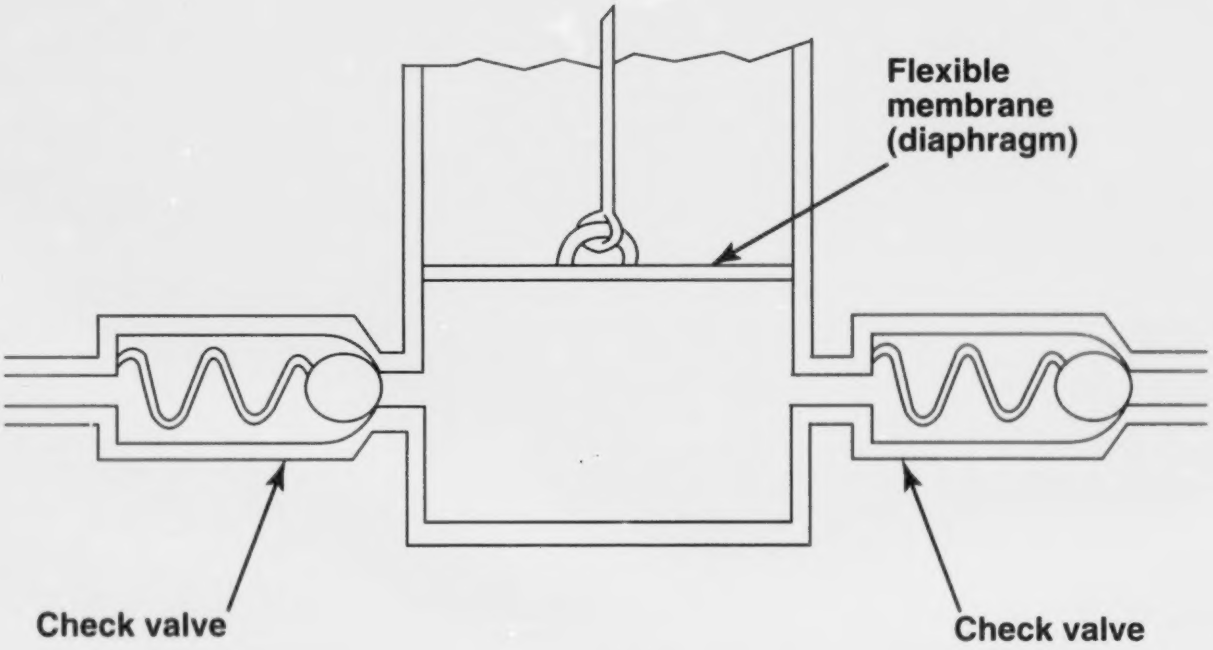
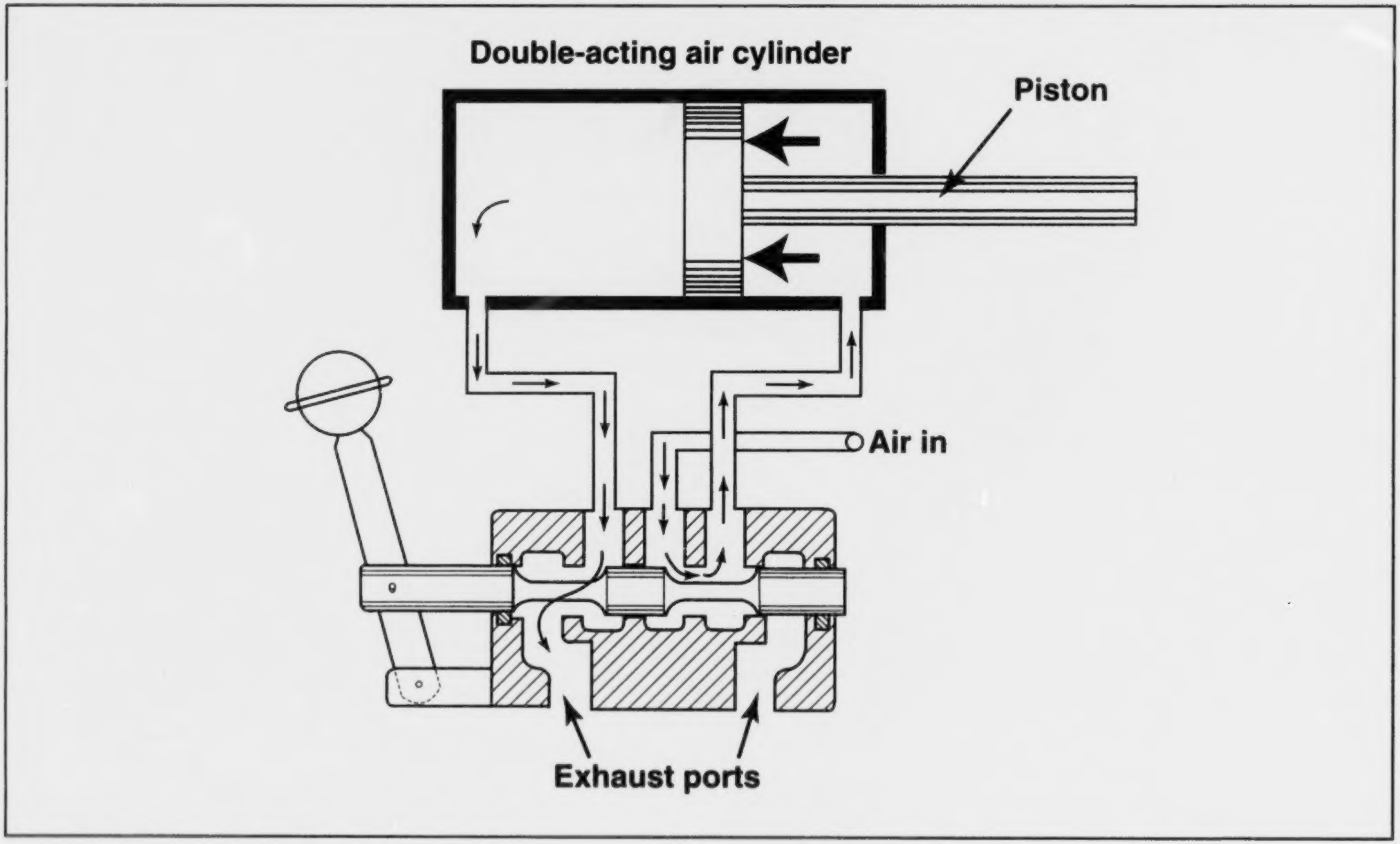
Types of Pneumatic Pumps: Diaphragm

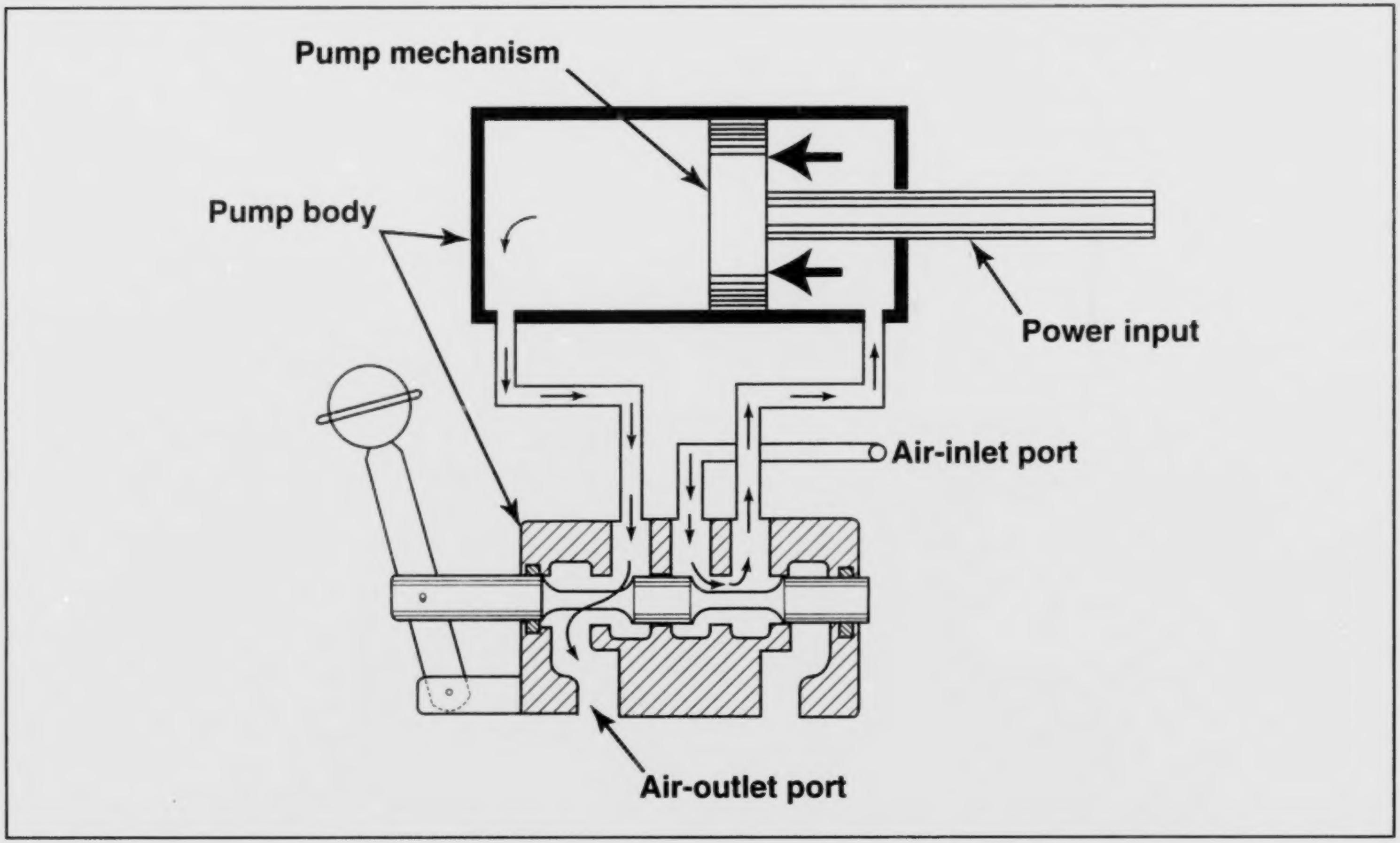

Flexible
membrane
(diaphragm)
Check valve
Check valve

Types of Pneumatic Pumps: Reciprocating


Double-acting air cylinder
Piston
Air in
Exhaust ports

Drawing reproduced by permission of the publisher, Womack Educational Publications, from *Industrial Fluid Power,* Volume 1, 3rd ed., prepared by Charles S. Hedges, copyright 1997.

Major Components of Pneumatic Pumps


Pump mechanism
Pump body
Power input
Air-inlet port
Air-outlet port

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Job Sheet 1

Worksheet—Measure Hydraulic-System Temperature

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Worksheet—Measure Hydraulic-System Temperature

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 2

Worksheet—Measure Hydraulic-System Pressure

Name

Attempt number

Date

Part A: Pre-performance check

Job

- Complete the following information concerning the assigned equipment.

  Equipment brand

  Equipment model/type and code

- Complete the following service-manual information.

  Service-manual title

  Section/page number of procedure

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature

Job Sheet 2

Worksheet—Measure Hydraulic-System Pressure

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 3

Worksheet—Measure Hydraulic-System Flow

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 3

Worksheet—Measure Hydraulic-System Flow

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 4

Worksheet—Measure Air Pressure

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

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Instructor's signature ______________________________

Job Sheet 4

Worksheet—Measure Air Pressure

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 5

Worksheet—Measure Airflow

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 5

Worksheet—Measure Airflow

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	________
Procedures completed correctly.	________
Proper tools used correctly.	________
Safety precautions observed.	________
Service meets specifications.	________
Clean-up and follow-up actions adequate.	________
Overall rating	________

Evaluator's comments ____

____

____

Hydraulic and Pneumatic Drive Systems
Unit 4

Suggested Activities

Instructional plan

Preparation

- Review the unit in the student edition and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Prepare the classroom by displaying posters, equipment, and tools related to hydraulic and pneumatic drive systems.

- Make transparencies from the transparency masters included in the teacher pages of this unit.

- Select teacher components (written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution.

- Review the job sheets in the student edition and locate the worksheet masters included in the teacher pages of this unit. Copy and prepare extra worksheets for distribution to your students.

Delivery and application

Unit introduction

The skill areas appearing in bold-face type in the unit introduction and teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want.* These have been adapted by MAVCC.

- Provide the students with the student materials. You may choose to begin by discussing the objective sheet. Review the unit and specific objectives with the students. Discuss how meeting the unit objective will improve your students' employability or will increase their value as an employee. Explain how the specific objectives support the unit objective. **(Listening; oral communication; adapting to the organization's modes of operation; emphasizing personal and career development)**

Suggested Activities

Teaching suggestions

Objective 1 Distinguish between descriptions of the types of clutches used with hydraulic and pneumatic drive systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Provide illustrations and actual equipment to support the discussion. If possible, exhibit various types of clutches, such as mechanical clutches that use belts, centrifugal clutches, jaw clutch, etc. Discuss how and why power is removed in the various examples. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information)**

- Relate the terms to concepts that the students already understand. For example, if the students have completed the units on mechanical drive trains and principles of hydraulics and pneumatics, correlate drive-system components and functioning to the mechanical drive systems and principles of fluid power. **(Listening; reasoning; system interrelationships)**

Objective 2 Distinguish between descriptions of the types of hydraulic drive trains used in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Relate the operation of automatic and hydrostatic drive trains to concepts that the students have mastered in their previous studies, such as the operation of gears in engines and governors. Use actual equipment to demonstrate the operation of each type of hydraulic drive train. Provide an overview of applications and associated service procedures for each type. Discuss applications of each type, emphasizing those that will be covered in your course. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 3 State the functions of the major components of hydrostatic drive trains.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 1, "Major Components of Hydrostatic Drive Trains," to aid the discussion. **(Reading/listening for content)**

- Point out that most hydraulic drive systems used on power product equipment are hydrostatic, which is why this type is used for the typical system. Explain reasons for the prevalence of hydrostatic systems (lower cost, less complexity, limited need for on-the-go shifting, etc.). Provide actual examples of both types of hydraulic drive trains and give an overview of how they are similar to and different from automatic drive trains. Discuss how both types fit into your course schedule. Have the students identify both types of drive trains on equipment in your facility. Relate the operation of hydraulic drive trains to the remaining specific objectives of this unit. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 4 Complete statements about the principles of operation of hydrostatic drive trains.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use flow diagrams and other illustrations to show the flow of power through hydrostatic drive trains. Lead the students in discussing advantages and disadvantages of hydraulic systems versus mechanical systems and automatic versus hydrostatic (cost, complexity, weight, periodic maintenance, etc.). Discuss hydrostatic drive-train malfunctions and causes. Display troubleshooting charts and discuss their application. Relate service procedures to the operation and maintenance of such systems. Point out subsystems, such as charge pumps and filters, and discuss their roles in the proper operation of the drive train. Point out how the drive train interfaces with actuators, neutral safety switches, differentials, and other equipment systems. Discuss systems that have one speed and one direction as well as those that have both forward and reverse capabilities and multiple speeds. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

- Discuss the purpose and functioning of variable-displacement pumps. Explain how power is affected and transferred through the system. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 5 Complete statements about the principles of operation of axial-piston hydraulic pumps.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 2, "Major Components of Axial-Piston Hydraulic Pumps," to aid the discussion. **(Reading/listening for content)**

- Provide actual equipment to discuss the operation of axial-piston hydraulic pumps. Relate each of the components to the general operation of hydraulic pumps previously discussed. Discuss variations in swashplate and piston designs. Describe the flow of power from the pump and the reflection of those actions in a hydraulic motor. Discuss how to change displacement and why it needs to be changed for different purposes. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Suggested Activities

Objective 6 Complete statements about the principles of operation of radial-piston hydraulic pumps.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 3, "Major Components of Radial-Piston Hydraulic Pumps," to aid the discussion. **(Reading/listening for content)**

- Provide actual equipment to discuss the operation of radial-piston hydraulic pumps. Relate each of the components to the general operation of hydraulic pumps previously discussed, including axial-piston pumps. Discuss variations in drive-shaft and piston designs. Describe the flow of power from the pump and the reflection of those actions in a hydraulic motor. Discuss reasons for using an odd number of pistons to avoid lockup. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 7 Label types of hydrostatic drive trains as classified by their pump and motor designs.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparencies 4 through 6 to aid the discussion. **(Reading/listening for content)**

- Provide actual equipment to describe the operation of hydrostatic drive trains. Relate the information to the objectives about pumps and to mechanical drive systems (if the students have studied that unit). Discuss the flow of power through the various configurations. Exhibit equipment and service manuals for the various types of configurations. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

- Review the types of pumps and motors discussed in the previous unit. Discuss their applications in hydrostatic drive trains. Explain why variable-displacement pumps are used in some applications and not in others. Discuss reasons for using hydraulic motors of different designs. For example, explain why it is not necessary to use an axial-piston motor with an axial-piston pump. Provide examples of each type of drive train in equipment applications. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 8 Complete statements about the principles of operation of hydraulic equipment drives.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Provide actual equipment to discuss the design and operation of hydraulic equipment drives. Relate the operation of hydraulic equipment drives to principles of operation and hydraulic drive trains. Discuss the various sources of hydraulic power used to drive equipment. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Suggested Activities

Objective 9 List typical service procedures required for hydraulic drive systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Discuss service procedures and their applicability to specific systems. Display service manuals that cover these procedures and demonstrate each. Allow student practice in support of the job sheets. Discuss the dangers of contaminants and high temperatures to equipment. Discuss the selection of hydraulic fluids and the use of the recommended fluids. Discuss dangers of hydraulic-system service, including high-pressure systems. Display special tools and demonstrate their use and care. Demonstrate symptoms of ineffective hydraulic drive trains. **(Listening; reasoning; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

Objective 10 Describe the types of pneumatic power used to accomplish work in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Demonstrate how both moving air and pressure differential are used to accomplish work in power product equipment. Exhibit the power sources both as general scientific principles and as specific equipment applications. Discuss advantages and disadvantages of each type of power source in specific applications. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 11 State the functions of the major components of pneumatic drive systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 7, "Major Components of Pneumatic Drive Systems," to aid the discussion. **(Reading/listening for content)**

- Relate the operation of these systems to concepts that the students have mastered in their previous studies, such as the operation of hydraulic drive systems. Use actual equipment to demonstrate the operation of each type of pneumatic drive system. Provide an overview of applications and associated service procedures for each type. Discuss applications of each type, emphasizing those that will be covered in your course. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 12 Complete statements about the principles of operation of pneumatic equipment drives.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

Suggested Activities

- Use flow diagrams and other illustrations to show the flow of power through pneumatic equipment drives. Adjust the time and activities in support of this objective as appropriate to your emphasis in the course. Discuss equipment-drive malfunctions and causes and the importance of proper throttle adjustments. Display troubleshooting charts and discuss their application. Relate service procedures to the operation and maintenance of such systems. Display a variety of different designs featuring various types of components, such as different types of inputs and ducting. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 13 List typical service procedures required for pneumatic drive systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Discuss service procedures and their applicability to specific systems. Display service manuals that cover these procedures and demonstrate each. Allow student practice in support of the job sheets. Discuss the selection of lubricants, filters, etc. Discuss dangers of pneumatic-system service, including high-pressure systems and impellers. Display special tools and demonstrate their use and care. **(Listening; reasoning; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

Assignment Sheet 1 Determine hydraulic and pneumatic drive-system service specifications and parts requirements

- Have students locate Assignment Sheet 1. Read the introduction and directions to the assignment. **(Reading/listening for direction)**

- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to the equipment used in your facility. **(Listening; reasoning; writing; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

- Answer any student questions and have students complete Assignment Sheet 1.

Job Sheet 1 Perform routine maintenance on hydraulic drive trains.

- Have students locate Job Sheet 1 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on hydraulic drive trains. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

Suggested Activities

- Provide students with power product equipment that requires routine maintenance of the hydraulic drive-train system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 1.

Job Sheet 2 Repair hydraulic drive trains.

- Have students locate Job Sheet 2 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing hydraulic drive trains. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the hydraulic drive-train system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 2.

Job Sheet 3 Perform routine maintenance on hydraulic equipment drives.

- Have students locate Job Sheet 3 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on hydraulic equipment drives. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the hydraulic equipment drive and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 3.

Job Sheet 4 Repair hydraulic equipment drives.

- Have students locate Job Sheet 4 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing hydraulic equipment drives. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the hydraulic equipment drive and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 4.

Suggested Activities

Job Sheet 5 Perform routine maintenance on pneumatic equipment drives.

- Have students locate Job Sheet 5 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on pneumatic equipment drives. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment that requires routine maintenance of the pneumatic equipment drive and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 5.

Job Sheet 6 Repair pneumatic equipment drives.

- Have students locate Job Sheet 6 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing pneumatic equipment drives. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment that requires repair of the pneumatic equipment drive and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 6.

Evaluation

- Evaluate the assignment sheet. See the evaluation criteria listed at the top of each assignment sheet as well as the teacher page "Answers to Assignment Sheet."
- Evaluate the job sheets.

  When the student is ready to perform a specific task, obtain a copy of the worksheet associated with each job sheet. Worksheets may be found in the student edition and in the teacher pages following the transparency masters. Then, observe the student performing the procedure.

  After the student has completed the procedure, rate the student using the criteria provided on the worksheet. If the student's performance is unacceptable, have the student review the materials and perform the procedure again for evaluation.

  Two sample performance evaluation keys are provided on the next page. Many other keys are available. Select one evaluation key (grading scale) that best fits your program needs.

Suggested Activities

Performance Evaluation Keys

Sample A

4 — Skilled—Can perform job with no additional training.
3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
1 — Unskilled—Is familiar with process, but is unable to perform job.

Sample B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

- Give the written test. See the teacher page "Written Test."
- Evaluate the written test. See the teacher page "Answers to Written Test."
- Compile written-test, assignment-sheet, and job-sheet scores. See the teacher page "Unit Evaluation Form."
- Reteach and retest as required.

Suggested resources

Resources used in developing this unit

Print media

- Graf, Rudolf F., and George J. Whalen. *VNR Illustrated Guide to Power Tools.* New York: Van Nostrand Reinhold Company, 1978.
- Hawker, M. F. J., and J. F. Keenlyside. *Horticultural Machinery,* 3rd ed. Essex, England: Longman Group Limited, 1985.
- Hedges, Charles S. *Industrial Fluid Power,* 3rd ed. Dallas, Texas: Womack Educational Publications, 1984.
- Jorgensen, Eric, editor. *Kawasaki 250-750cc Triples,* 5th ed. Arleta, California: Clymer Publications, 1979.
- *MTD Yard-Man Technical Service Handbook*. Cleveland, Ohio: MTD Products, Inc., 1996.
- *Outdoor Power Equipment Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1985.
- *Power Tools and Equipment.* Alexandria, Virginia: Time-Life Books, Inc., 1989.

- *Power Trains: Compact Equipment.* Moline, Illinois: Deere and Company, 1991.
- *Riding Lawn Mower Service Manual,* 3rd ed. Overland Park, Kansas: Intertec Publishing Corporation, 1989.
- *Small Tractor Service Manual.* Overland Park, Kansas: Intertec Publishing Corporation, 1984.
- Stewart, Harry L. *Hydraulics for Off-the-Road Equipment.* Indianapolis, Indiana: Theodore Audel and Co., 1978.
- Wright, Ron. *Harley-Davidson Sportsters,* 7th ed. Arleta, California: Clymer Publications, 1986.
- *Yard and Garden Tractor Service Manual,* 1st ed. Overland Park, Kansas: Intertec Publishing Corporation, 1992.

Suggested supplemental resources

Print media

- *Outdoor Power Equipment* magazine. Adams/Green Industry Publishing, 68860 Perez Road, Suite J, Cathedral City, California 92234. Web site: http://www.outdoorpowerequipment.com
- *Power Equipment Trade* magazine. Hatton-Brown Publishers, Inc., P. O. Box 2268, Montgomery, Alabama 36102.
- *Technical Handbook.* Describes the makes and types of equipment produced by MTD—one of the nation's largest manufacturers. The book covers service for most equipment systems and various types of equipment. Both light- and heavy-duty equipment types are included. Available from MTD Products, Inc. Call 1-800-422-3381.
- Service manuals for systems covered in this unit.
- Parts catalogs for systems covered in this unit. Available from equipment manufacturers.

Non-print media

- *Centrifugal Pump Maintenance.* Arthur Mokin Productions, P.O. Box 1866, Santa Rosa, California 95402, (707) 542-4868.
- *Centrifugal Pump Operation.* L and K International Videotraining, P.O. Box 940 Station U, Toronto, Ontario M8Z 5P9, Canada, (416) 252-6407.
- *Centrifugal Pumps.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Energy Transmission Using a Pneumatic System.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.

Suggested Activities

- *Force Transmission Through a Fluid.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Gear Pumps and Vane Pumps.* L and K International Videotraining, P.O. Box 940 Station U, Toronto, Ontario M8Z 5P9, Canada, (416) 252-6407.
- *Hydraulic Equipment.* Industrial Training Corporation, 13515 Dulles Technology Drive, Herndon, Virginia 22070, (800) 638-3757.
- *Hydraulic Motors.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Hydraulic Transmission of Force and Energy.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Operation at the Suction Side of the Pump.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *The Physical World of a Machine.* Tel-A-Train, 309 North Market Street, P.O. Box 4752, Chattanooga, Tennessee 37405, (800) 266-0113.
- *Pump Operations.* Industrial Training Corporation, 13515 Dulles Technology Drive, Herndon, Virginia 22070, (800) 638-3757.
- *Two Speed Transmission Disassembly and Repair.* This program is available in pre- and post-1997 editions. The videotapes cover the action of the transmission as well as the disassembly and assembly of this popular transmission. This program is also suitable for use with *Lawn and Garden Equipment,* Unit 3. Available from MTD Products, Inc. Call 1-800-422-3381.
- *Z Series Transmission, Repair and Neutral Adjustment Instructions.* Addresses this model of transmission used in Cub Cadet and White models of riding lawn mowers and garden tractors. Covers step-by-step transmission removal and replacement. This program is also suitable for use with *Lawn and Garden Equipment,* Unit 3. Available from MTD Products, Inc. Call 1-800-422-3381.
- *Special Five Tapes in One.* Section 3 of this program provides information on setting the neutral and troubleshooting the IHT hydrostatic transaxle. Available from MTD Products, Inc. Call 1-800-422-3381.

Hydraulic and Pneumatic Drive Systems
Unit 4

Answers to Assignment Sheet

Assignment Sheet 1—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

Part A

1. Radial piston to radial piston
2. No
3. $\frac{11}{32}$ inch
4. Loctite Grade 635
5. 15 ft-lbs (20 N•m)

Part B

6. Axial piston to axial piston
7. The pump valve plate has two relief notches and the motor valve plate has two notches.
8. 30 ft-lbs (41 N•m)
9. With 0.100 inch (2.54 mm) above machined surface
10. 7 quarts (6.6 liters)

Part C

11. Axial piston to axial piston
12. Gerotor
13. 0.001 inch (0.025 mm)
14. Dexron ATF
15. Neutral

Part D

16. Axial piston to gear
17. 0.002 inch (0.05 mm)
18. Every 100 hours of operation or 12 months
19. 22 to 26 ft-lbs (30 to 35 N•m)
20. 3 ft-lbs (4 N•m)

Hydraulic and Pneumatic Drive Systems
Unit 4

Answers to Written Test

1. a. M
   b. V

2. a. H
   b. A

3. a. Allows the operator to select drive-train settings
   b. Provides the power to operate the primary pump and, in some cases, a charge pump
   c. Stores fluid for use in the system
   d. Converts input power to hydraulic pressure
   e. Moves the fluid from the reservoir to the primary pump
   f. Carry the fluid through the system
   g. Control the fluid flow through the system
   h. Responds to system pressure to produce the power output
   i. Transmits power to the final-drive components

4. a. Rotary
   b. motor
   c. volume
   d. faster
   e. pump
   f. differential; transaxle

5. a. charge; retracted
   b. input
   c. piston
   d. pistons; cylinders
   e. piston; cylinder
   f. output
   g. piston; cylinder; reservoir

6. a. charge
   b. cylinder
   c. ball
   d. rotational
   e. motor

7. a. Axial piston to gear
   b. Axial piston to axial piston
   c. Radial piston to radial piston

8. a. pump
   b. pump; hydraulic fluid
   c. pistons; valves

Answers to Written Test

9. Answer should include any five of the following.

- Check fluid level
- Inspect seals
- Service input-drive components
- Service output-drive components
- Replace filters
- Change fluid
- Overhaul hydraulic components
- Adjust system components
- Remove and replace transmission or transaxle

10. a. Equipment uses moving air to exert pressure against a mechanism or object to accomplish work
    b. Equipment uses areas of high or low pressure to accomplish work

11. a. Allows air to enter the system
    b. Brings air into the system
    c. Routes air to the desired location
    d. Applies air to the work to be done
    e. Allows air to exit the system

12. a. air pump
    b. low-pressure; air pump; inlet
    c. impeller blades; blades
    d. escape
    e. work

13. Answer should include any five of the following.

- Check airflow or pressure
- Inspect seals
- Service input-drive components
- Service output-drive components
- Replace filters
- Balance impeller
- Overhaul pneumatic components
- Adjust system components
- Remove and replace air pump

Hydraulic and Pneumatic Drive Systems
Unit 4

Written Test

Name ______________________________ Score ______________

1. Distinguish between descriptions of the types of clutches used with hydraulic and pneumatic drive systems. Write an "M" beside the statement below that describes a mechanical clutch and write a "V" beside the statement that describes a valve clutch.

   _______ a. Input power is disengaged from the drive system so that speed or directional changes can be made

   _______ b. Valves within the system are used to redirect pressure flow or change the amount of pressure without removing input power

2. Distinguish between descriptions of the types of hydraulic drive trains used in power product equipment. Write an "A" beside the statement below that describes an automatic drive train and write an "H" beside the statement that describes a hydrostatic drive train.

   _______ a. Hydraulic drive train in which the engine drives a hydraulic pump, which in turn transmits power to a hydraulic motor that drives the wheels; gear changes are normally accomplished by the operator's positioning an actuator in a desired position

   _______ b. Hydraulic drive train in which changes in the load and vehicle speed control the positioning of valves, clutch pistons, and bands to produce gear shifts with no operator action other than throttle control

3. State the functions of the major components of hydrostatic drive trains. Write your answers on the blanks provided beside each of the components listed below.

   a. Control lever ______________________________

   ____

   b. Power input ______________________________

   ____

   c. Reservoir ______________________________

   ____

   d. Primary pump ______________________________

   ____

   e. Charge pump ______________________________

   ____

f. Lines ____

____

g. Valves ____

____

h. Motor ____

____

i. Output shaft ____

____

4. Complete statements about the principles of operation of hydrostatic drive trains. Write the missing word(s) on the blanks provided in the statements below.

   a. ________________ power from the engine drives a hydraulic pump.

   b. In the simplest designs, a rotary pump, such as a gerotor design, pressurizes fluid in the system and the pressurized fluid produces rotation within a hydraulic ________________.

   c. In more-complex designs, variable-displacement pumps are used, which allow the control of the fluid-flow ________________.

   d. The amount of displacement controls the volume of fluid flow so that the more flow allowed, the ________________ the motor operates.

   e. In some designs, the input shaft also drives a separate charge ________________ that is used to bring fluid from the reservoir into the active flow paths.

   f. The output of the hydraulic motor is either directed through a ________________ or is integrated into a ________________ to turn the drive axle.

5. Complete statements about the principles of operation of axial-piston hydraulic pumps. Write the missing word(s) on the blanks provided in the statements below.

   a. A ________________ pump moves fluid from the reservoir to the pump pistons when they are ________________ in their cylinders.

   b. The ________________ shaft causes the swashplate to rotate.

c. The swashplate is set at an angle, with the base of each ____________________ resting against the swashplate.

d. The rotation of the swashplate causes the ____________________ to move forward in their ____________________, which moves fluid to the motor.

e. The incoming fluid pushes a ____________________ back in its ____________________, which causes the swashplate to turn.

f. The turning swashplate causes the ____________________ shaft to rotate.

g. As the tilt of the motor swashplate pushes the ____________________ forward in its ____________________, fluid is forced into the return lines, which carry fluid back to the ____________________.

6. Complete statements about the principles of operation of radial-piston hydraulic pumps. Write the missing word(s) on the blanks provided in the statements below.

a. A ____________________ pump moves fluid from the reservoir to the pump.

b. Fluid entering the pump flows into a ____________________ as it rotates past the inlet port.

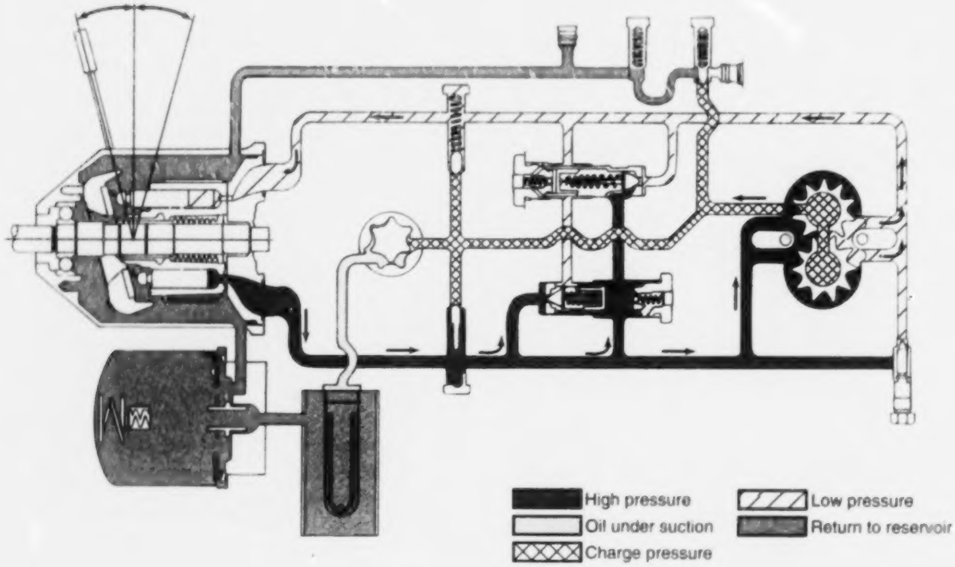
c. The ____________________ piston squeezes fluid through the outlet port as it passes that port.

d. As fluid flows into the motor, it enters cylinders and pushes past the ball pistons, creating a ____________________ force.

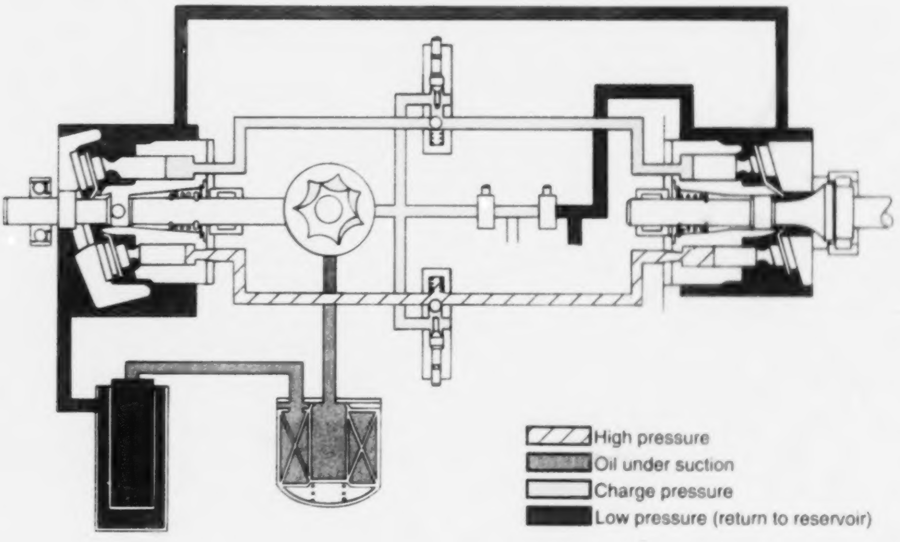
e. Fluid flows through the ____________________ and into a return line that takes the fluid back to the pump or to the reservoir, depending on pressure levels.

Written Test

7. Label types of hydrostatic drive trains as classified by their pump and motor designs. Write your answers on the blanks under each of the illustrations below and on the next page.

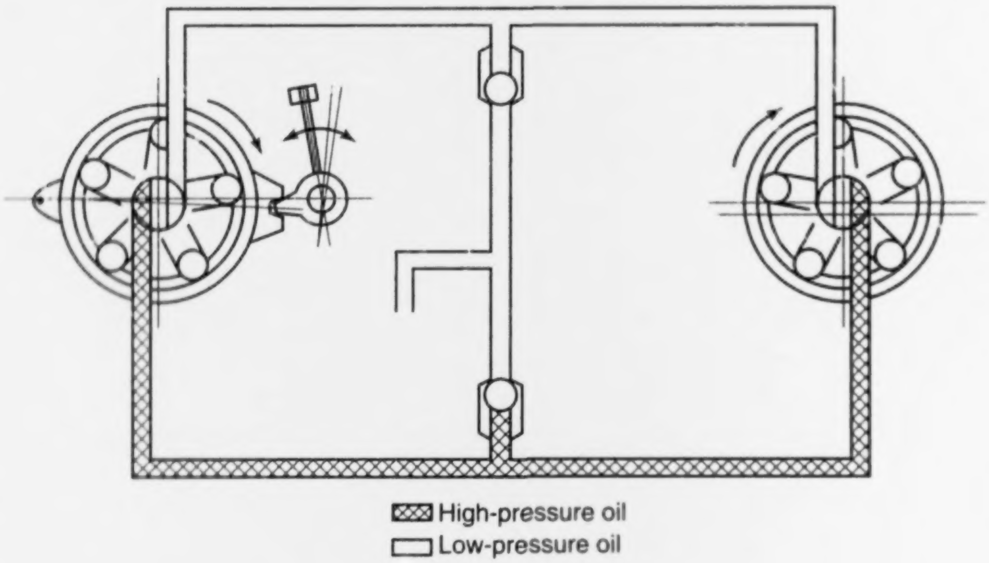

High pressure
Oil under suction
Charge pressure
Low pressure
Return to reservoir

a. ______________________________


High pressure
Oil under suction
Charge pressure
Low pressure (return to reservoir)

b. ______________________________

Written Test



c. ____

Drawing in Test-item 7-c reproduced by permission of the Eaton Corporation, Eden Prairie, Minnesota.

8. Complete statements about the principles of operation of hydraulic equipment drives. Write the missing word(s) on the blanks provided in the statements below.

   a. The engine output is used to drive a ____________.

   b. The ____________ pressurizes ____________ to produce a source of power.

   c. The hydraulic power is transmitted through a system of ____________ and ____________ to apply force to the equipment.

9. List five of the typical service procedures required for hydraulic drive systems. Write your answers on the blanks provided.

   a. ____

   b. ____

   c. ____

   d. ____

   e. ____

10. Describe the types of pneumatic power used to accomplish work in power product equipment. Write your answers on the blanks provided beside each of the terms below.

    a. Moving air ______________________________

    ____

    ____

    b. Pressure differential ______________________________

    ____

    ____

11. State the functions of the major components of pneumatic drive systems. Write your answers on the blanks beside each of the components listed below.

    a. Air intake ______________________________

    ____

    b. Air pump ______________________________

    ____

    c. Ducting ______________________________

    ____

    d. Output ______________________________

    ____

    e. Air outlet ______________________________

    ____

12. Complete statements about the principles of operation of pneumatic equipment drives. Write the missing word(s) on the blanks provided in the statements below.

    a. The engine drives the blade or impeller of an ____________.

    b. The rotation of the impeller creates a ____________ area on the back side of the impeller blades, causing air to move into the ____________ through an ____________.

    c. The continued rotation of the ____________ pushes air ahead of the ____________.

d. An opening in the air-pump body allows the air to __________________.

e. The air is directed to the location where __________________ is to be done.

13. List five of the typical service procedures required for pneumatic drive systems. Write your answers on the blanks provided.

a. ____

b. ____

c. ____

d. ____

e. ____

Permission to duplicate this test is granted.

Hydraulic and Pneumatic Drive Systems
Unit 4

Unit Evaluation Form

Student name ____________________ Unit rating __________

Assignment-sheet rating

Assignment Sheet 1—Determine Hydraulic and Pneumatic Drive-System Service Specifications and Parts Requirements Rating ______

Comments: ____________________

Job-sheet ratings

Job Sheet 1—Perform Routine Maintenance on Hydraulic Drive Trains Rating ______

Comments: ____________________

Job Sheet 2—Repair Hydraulic Drive Trains Rating ______

Comments: ____________________

Job Sheet 3—Perform Routine Maintenance on Hydraulic Equipment Drives Rating ______

Comments: ____________________

Job Sheet 4—Repair Hydraulic Equipment Drives Rating ______

Comments: ____________________

Job Sheet 5—Perform Routine Maintenance on Pneumatic Equipment Drives Rating ______

Comments: ____________________

Unit Evaluation Form

Job Sheet 6—Repair Pneumatic Equipment Drives Rating ________

Comments: ____

____

Written-test scores

Pretest ________ Posttest ________ Other ________

Comments: ____

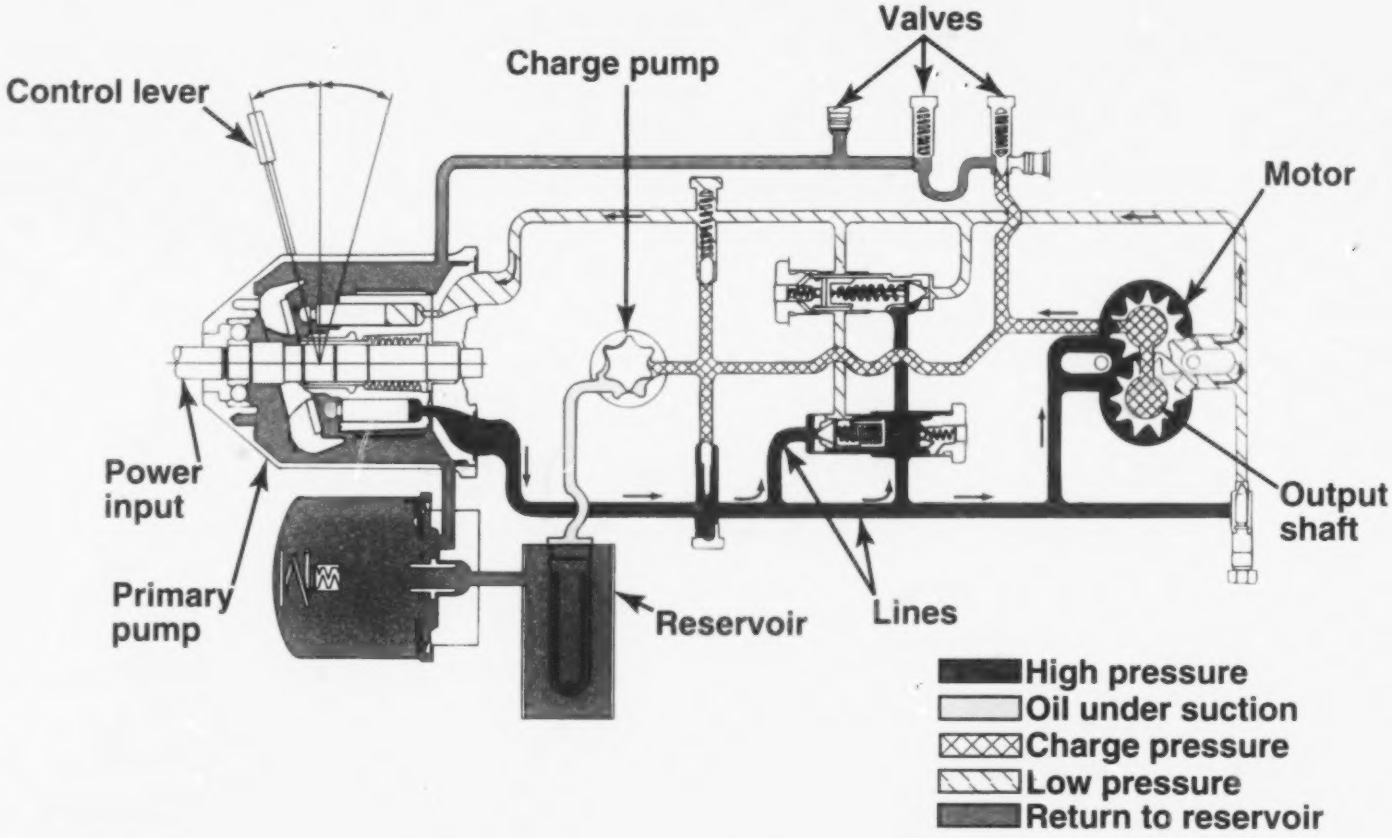
____

Teacher signature ______________________ Date ____________

Student signature ______________________ Date ____________

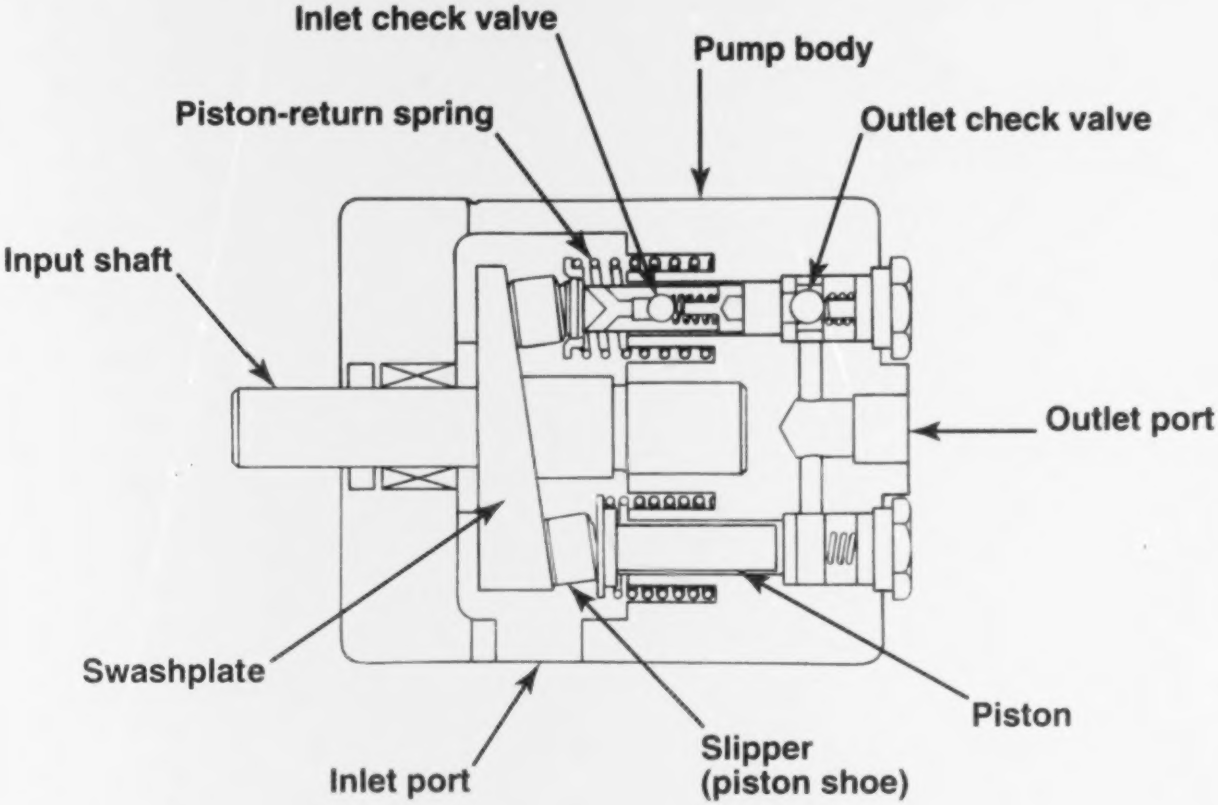
Permission to duplicate this form is granted.

Major Components of Hydrostatic Drive Trains


Valves
Charge pump
Control lever
Motor
Power input
Primary pump
Reservoir
Lines
Output shaft
High pressure
Oil under suction
Charge pressure
Low pressure
Return to reservoir

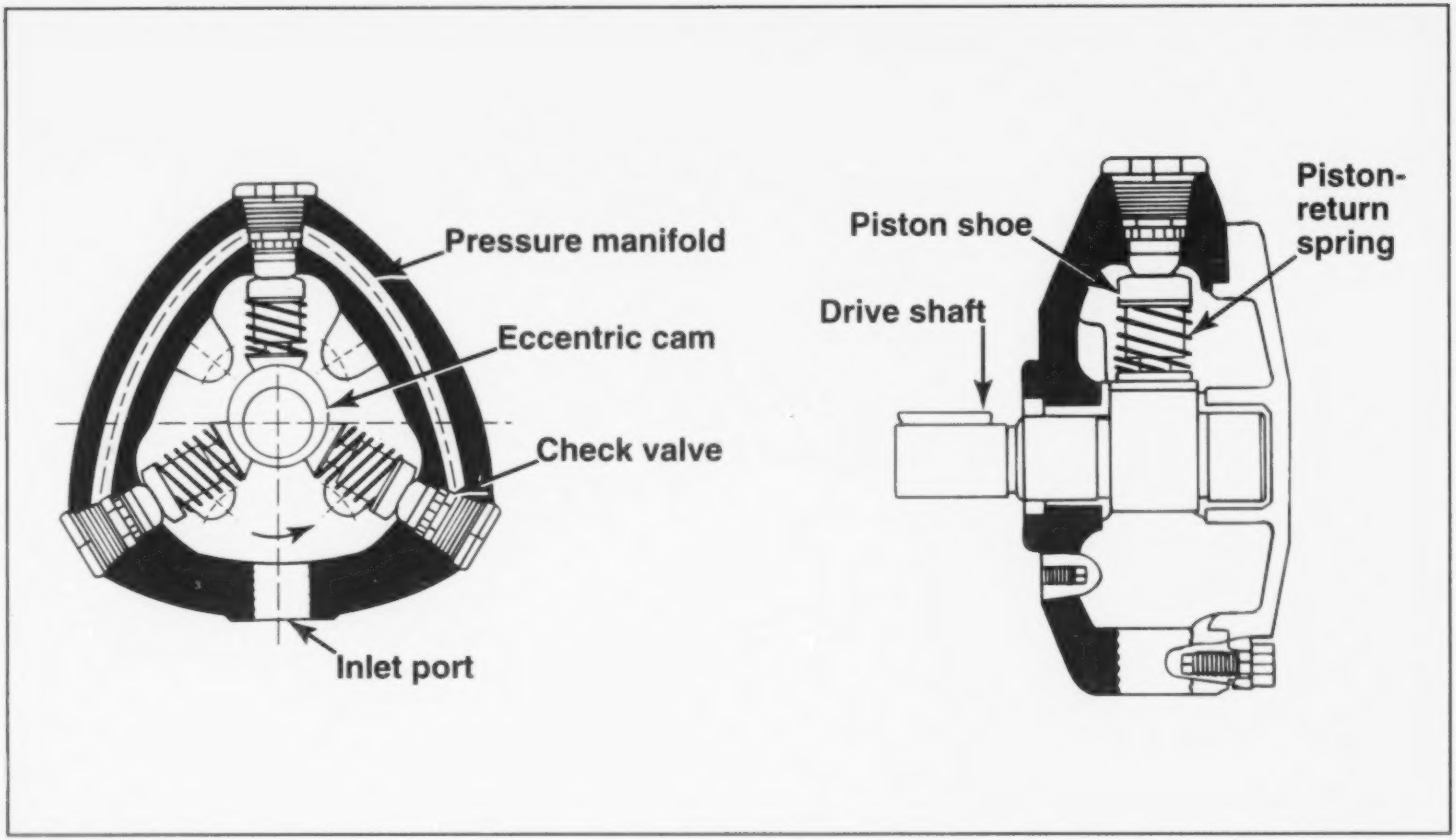
TM 1

Major Components of Axial-Piston Hydraulic Pumps


Inlet check valve
Pump body
Piston-return spring
Outlet check valve
Input shaft
Outlet port
Swashplate
Piston
Inlet port
Slipper
(piston shoe)

Drawing reproduced by permission of the publisher, Womack Educational Publications, from *Industrial Fluid Power,* Volume 1, 3rd ed., prepared by Charles S. Hedges, copyright 1997.

Major Components of Radial-Piston Hydraulic Pumps


Pressure manifold
Eccentric cam
Check valve
Inlet port
Piston shoe
Drive shaft
Piston-return spring

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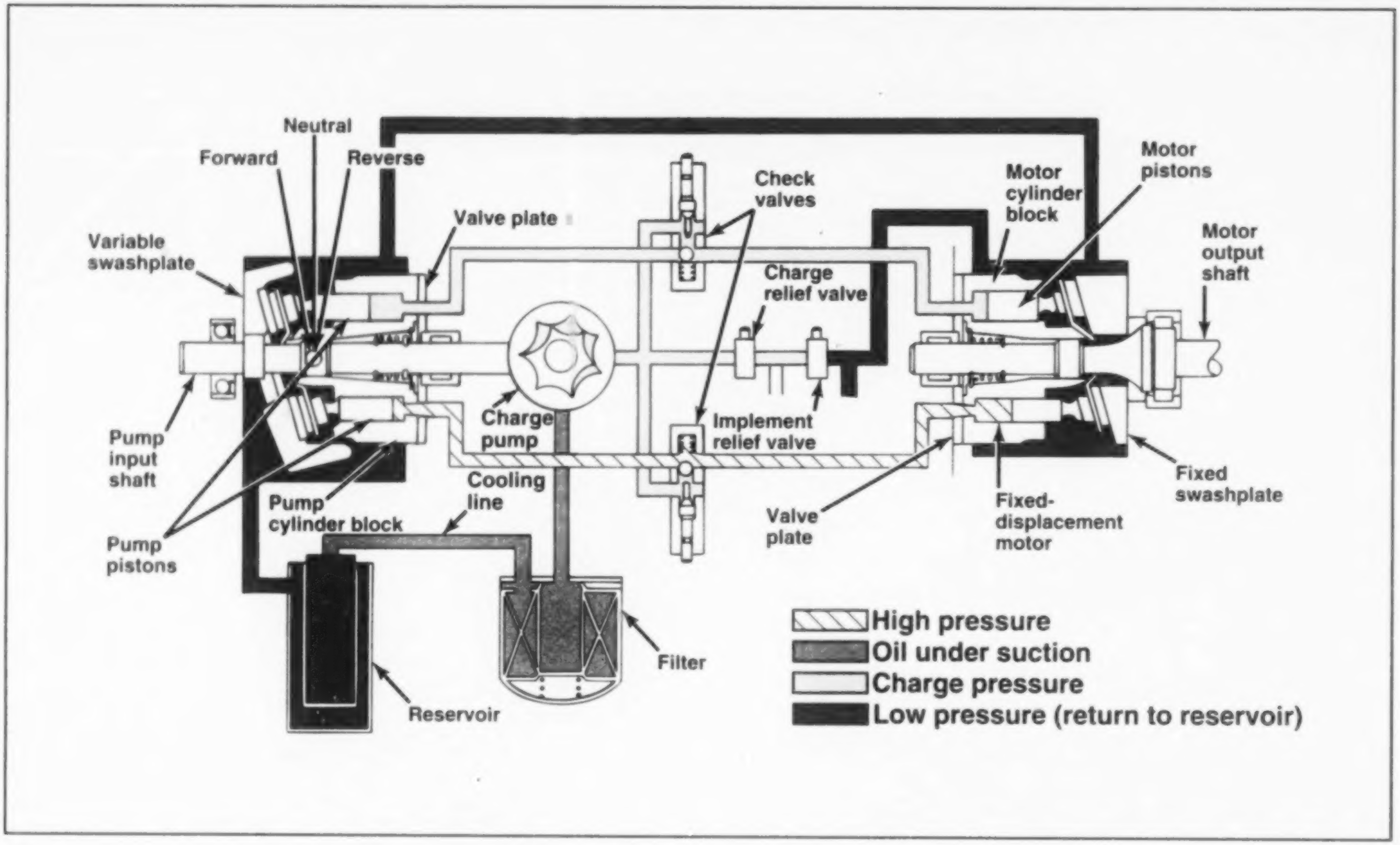
Equipment Systems, Unit 4
Teacher Page 225

TM 4

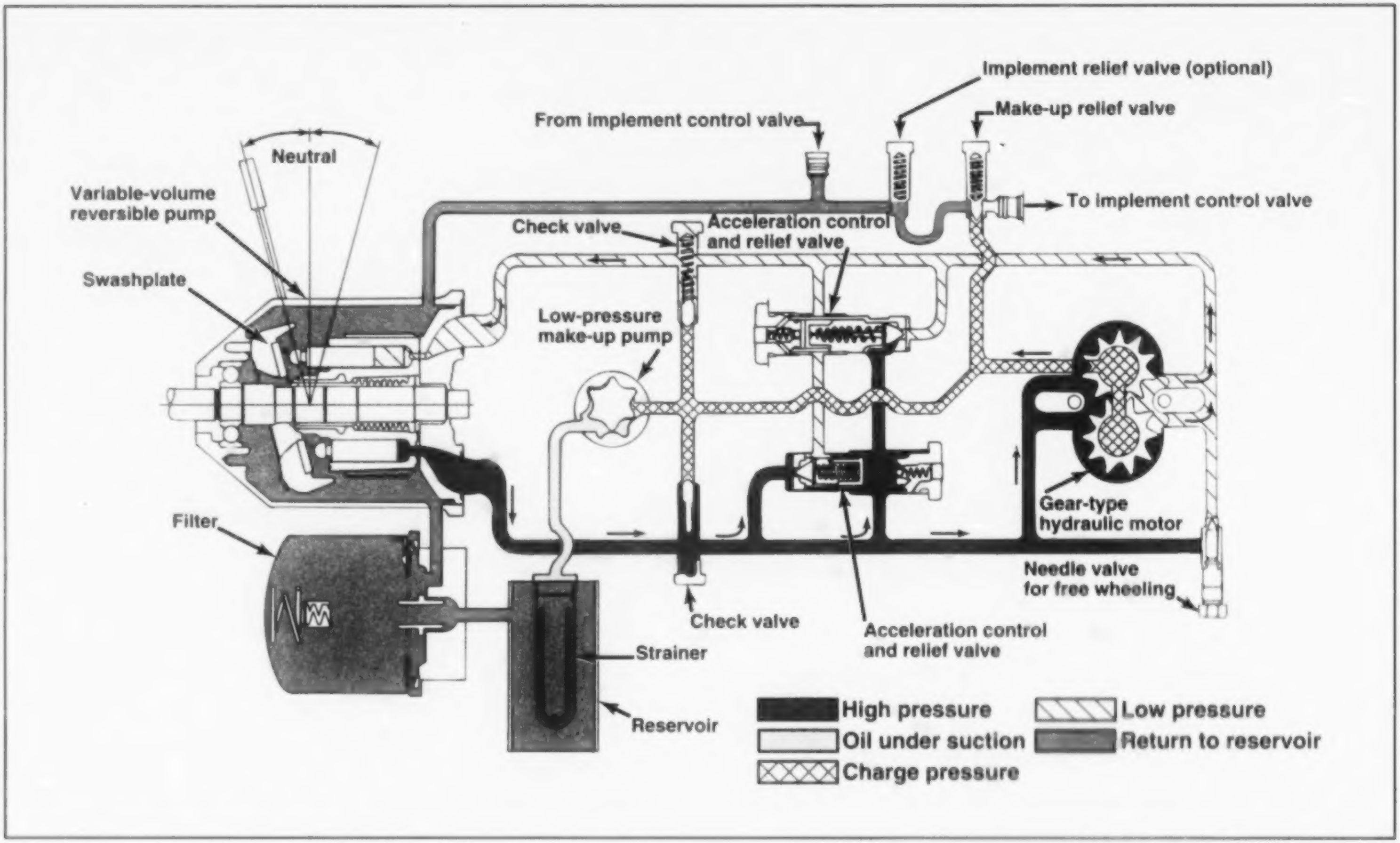
Types of Hydrostatic Drive Trains:

Axial-Piston-to-Axial-Piston Drive Train


Neutral
Forward
Reverse
Variable swashplate
Valve plate
Check valves
Charge relief valve
Motor cylinder block
Motor pistons
Motor output shaft
Pump input shaft
Charge pump
Implement relief valve
Pump cylinder block
Cooling line
Pump pistons
Valve plate
Fixed-displacement motor
Fixed swashplate
Filter
Reservoir
▨ High pressure
▩ Oil under suction
☐ Charge pressure
■ Low pressure (return to reservoir)

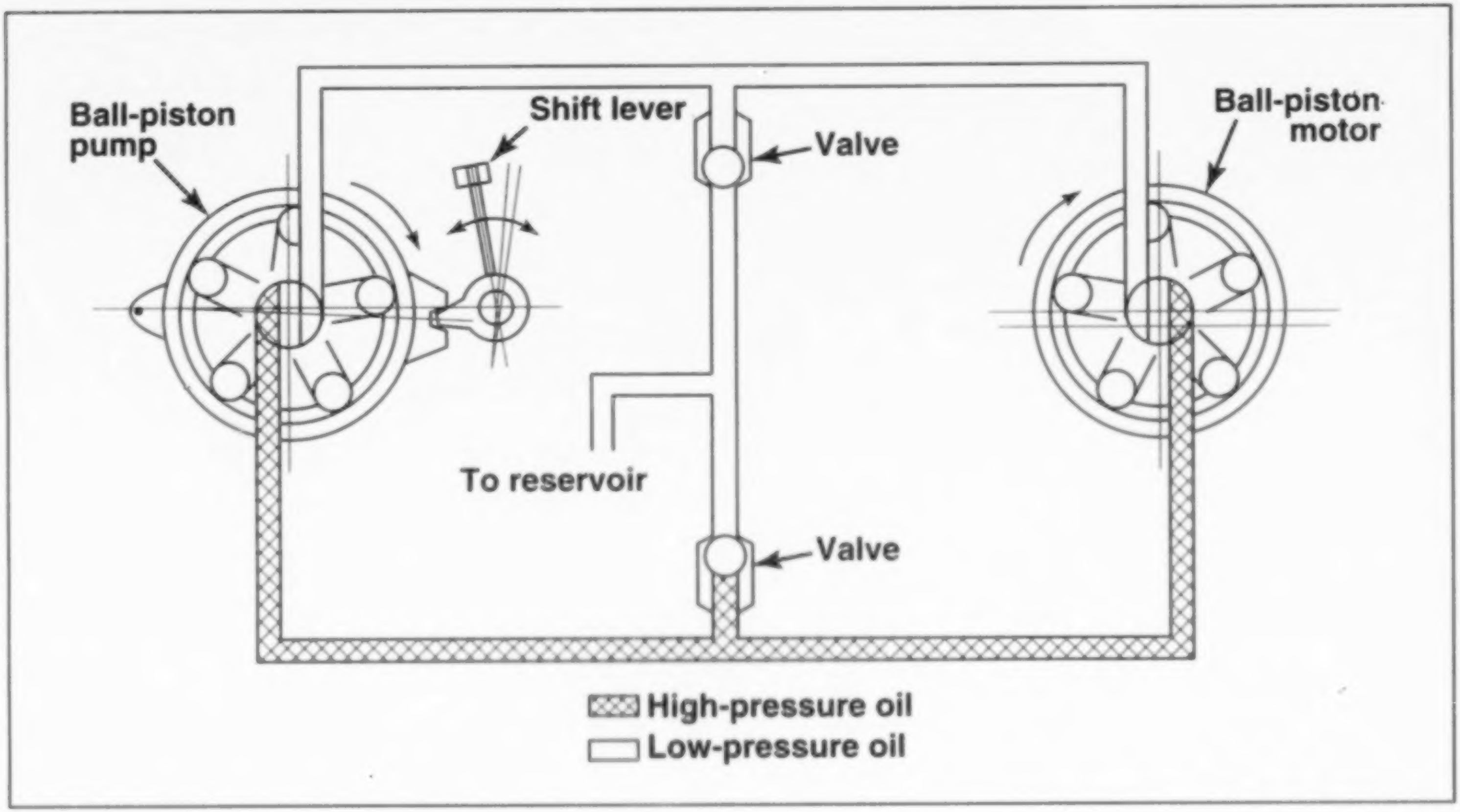
Types of Hydrostatic Drive Trains:

Axial-Piston-to-Gear Drive Train


Implement relief valve (optional)
Make-up relief valve
From implement control valve
To implement control valve
Neutral
Variable-volume reversible pump
Swashplate
Check valve
Acceleration control and relief valve
Low-pressure make-up pump
Gear-type hydraulic motor
Filter
Needle valve for free wheeling
Check valve
Acceleration control and relief valve
Strainer
Reservoir
High pressure
Oil under suction
Charge pressure
Low pressure
Return to reservoir

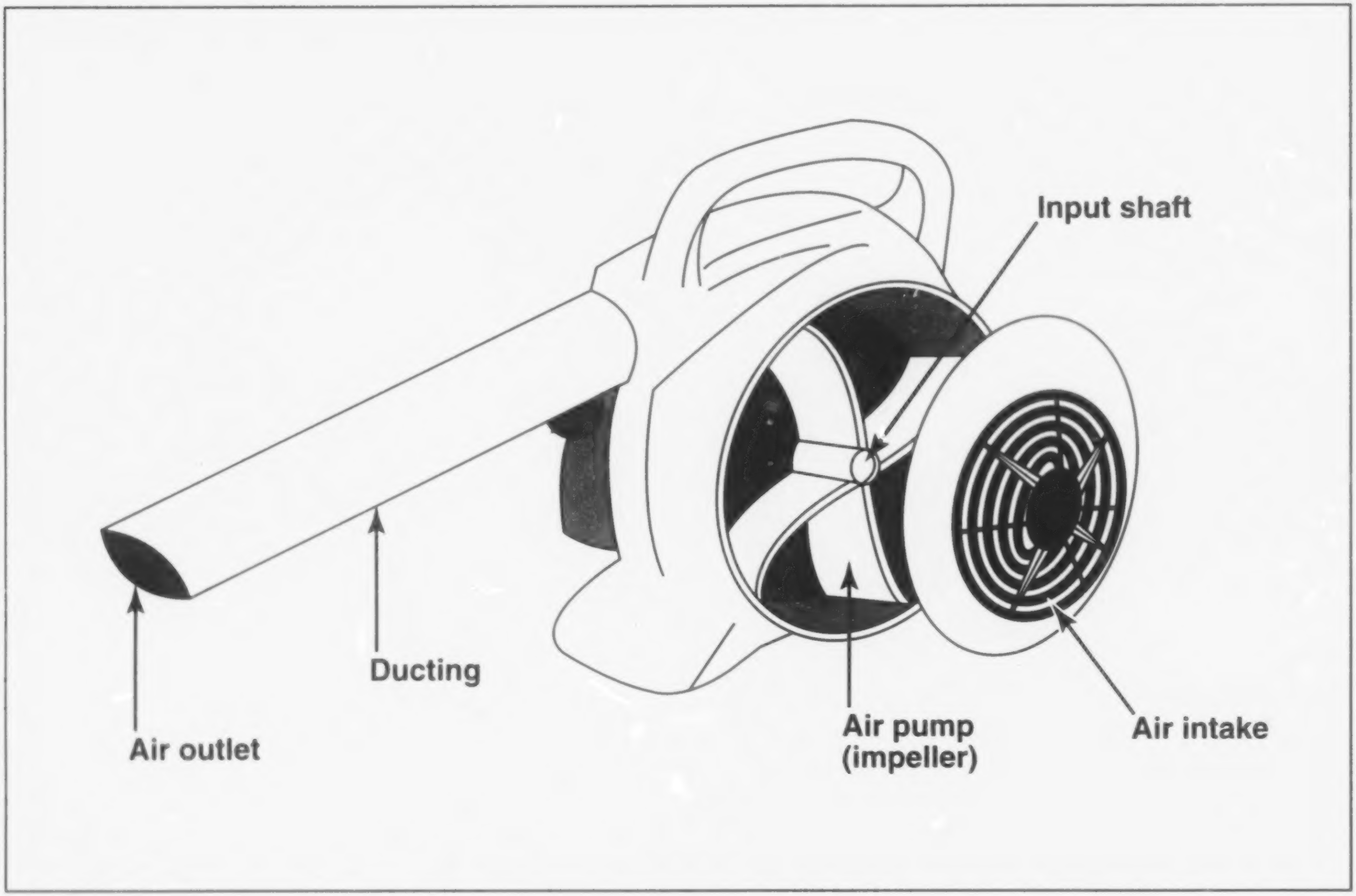
Types of Hydrostatic Drive Trains:

Radial-Piston-to-Radial-Piston Drive Train


Ball-piston pump
Shift lever
Valve
Ball-piston motor
To reservoir
Valve
▨ High-pressure oil
☐ Low-pressure oil

Drawing reproduced by permission of the Eaton Corporation, Eden Prairie, Minnesota.

Major Components of Pneumatic Drive Systems


Input shaft
Ducting
Air outlet
Air pump (impeller)
Air intake

Job Sheet 1

Worksheet—Perform Routine Maintenance on Hydraulic Drive Trains

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 1

Worksheet—Perform Routine Maintenance on Hydraulic Drive Trains

---

Part B: **Performance evaluation**

Evaluation criteria **Rating**

Correct procedures identified for assigned equipment. ______

Procedures completed correctly. ______

Proper tools used correctly. ______

Safety precautions observed. ______

Service meets specifications. ______

Clean-up and follow-up actions adequate. ______

Overall rating ______

Evaluator's comments ____

____

____

Job Sheet 2

Worksheet—Repair Hydraulic Drive Trains

Name ______________________ Attempt number __________

Date ______________________

Part A: **Pre-performance check**

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 2

Worksheet—Repair Hydraulic Drive Trains

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	
Procedures completed correctly.	
Proper tools used correctly.	
Safety precautions observed.	
Service meets specifications.	
Clean-up and follow-up actions adequate.	
Overall rating	

Evaluator's comments

Job Sheet 3

Worksheet—Perform Routine Maintenance on Hydraulic Equipment Drives

Name ______________________ Attempt number __________

Date ______________________

Part A: **Pre-performance check**

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 3

Worksheet—Perform Routine Maintenance on Hydraulic Equipment Drives

---

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 4

Worksheet—Repair Hydraulic Equipment Drives

Name ______________________ Attempt number ________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 4

Worksheet—Repair Hydraulic Equipment Drives

Part B: Performance evaluation

Evaluation criteria **Rating**

Correct procedures identified for assigned equipment. _______

Procedures completed correctly. _______

Proper tools used correctly. _______

Safety precautions observed. _______

Service meets specifications. _______

Clean-up and follow-up actions adequate. _______

Overall rating _______

Evaluator's comments ____

____

____

Job Sheet 5

Worksheet—Perform Routine Maintenance on Pneumatic Equipment Drives

Name ____________________ Attempt number __________

Date ____________________

Part A: Pre-performance check

Job ____________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ____________________

  Equipment model/type and code ____________________

  ____

- Complete the following service-manual information.

  Service-manual title ____________________

  Section/page number of procedure ____________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ____________________

Worksheet—Perform Routine Maintenance on Pneumatic Equipment Drives

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 6

Worksheet—Repair Pneumatic Equipment Drives

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 6

Worksheet—Repair Pneumatic Equipment Drives

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Wheel and Brake Systems
Unit 5

Suggested Activities

Instructional plan

Preparation

- Review the unit in the student edition and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Prepare the classroom by displaying posters, equipment, and tools related to tires, wheels, and brakes.
- Make transparencies from the transparency masters included in the teacher pages of this unit.
- Select teacher components (written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution.
- Review the job sheets in the student edition and locate the worksheet masters included in the teacher pages of this unit. Copy and prepare extra worksheets for distribution to your students.

Delivery and application

Unit introduction

The skill areas appearing in bold-face type in the unit introduction and teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want.* These have been adapted by MAVCC.

- Provide the students with the student materials. You may choose to begin by discussing the objective sheet. Review the unit and specific objectives with the students. Discuss how meeting the unit objective will improve students' employability or will increase their value as an employee. Explain how the specific objectives support the unit objective. **(Reading; listening; adapting to the organization's traditional modes of operation)**

Teaching suggestions

Objective 1 State the functions of the major components of tire and wheel assemblies.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 1, "Major Components of Tire and Wheel Assemblies," to aid your discussion. **(Reading/listening for content)**

Suggested Activities

- Provide examples of the components in a variety of tire and wheel designs. In all probability, few of your students have considered the variety of tire and wheel designs and the resulting variations in axles and wheel-support configurations. You may even want to introduce track drives used on snowmobiles and some snow blowers. Point out corresponding components in the various designs. Point out differences between tire and wheel assemblies used for steering axles and those used for drive axles, as well as free-wheeling assemblies. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 2 Match types of tires used in power product equipment to their correct descriptions.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 2, "Types of Tires," to aid your discussion. **(Reading/listening for content)**

- Provide actual examples of each type of tire and associate them with equipment applications. Discuss reasons for having different types of tires and wheels, including examples of types of equipment that have more than one type of tire. Point out the features of typical tires, such as tread and sidewalls, and discuss their role in tire functioning and service. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 3 List types of rims used in tire and wheel assemblies.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 3, "Types of Rims," to aid your discussion. **(Reading/listening for content)**

- Provide actual examples of rims and discuss rim construction. Demonstrate how tires are mounted on the various types of rims and how rims are mounted to hubs, axles, etc. Provide examples of rims with defects and discuss the importance of replacing defective rims. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

- Relate the discussion to the previous objectives by using a variety of tire and rim designs. Display a variety of actual equipment to show various ways of mounting tire and wheel assemblies. Include snap rings, threaded spindles, bolts through the hub, lug bolts, pins and bolts through the axle, and other methods of mounting tire and wheel assemblies. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 4 List types of wheel supports used in tire and wheel assemblies.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 4, "Types of Wheel Supports," to aid your discussion. **(Reading/listening for content)**

Suggested Activities

- Display a variety of types of bushings and bearings. Demonstrate how each type provides support and friction reduction, if applicable. Exhibit equipment that makes use of the various types of wheel supports being discussed. Discuss advantages and disadvantages of each type of support in specific applications, pointing out, for example, why a bearing may be preferable over a bushing in a specific application. Discuss and demonstrate service procedures. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 5 List typical service procedures required for tire and wheel assemblies.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Build on your discussion of wheel-support service procedures to discuss other types of service. Demonstrate service procedures for tires, tire and wheel assemblies, and support devices as applicable to those covered in your course. Emphasize the variety of tools available and how to use them as a lead-in for the next objective. Discuss safety precautions. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 6 Match specialty tools used in tire and wheel service to their correct uses.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Provide actual tools to aid in the discussion. Invite a tool supplier to meet with the class to discuss these tools, their use, and the latest developments in tire-and-wheel tool technology. Have the students use catalogs to cost a typical set of tire and wheel tools for power product equipment. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; using resources; budgeting; selecting tools)**

Objective 7 State safety rules for performing tire and wheel service.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Review safety precautions covered in the previous objectives to define safety rules applicable to the handling and maintenance of tires and tire and wheel assemblies. Review first-aid procedures and locations of first-aid resources that are likely to be required for accidents involving tire service procedures. **(Listening; reasoning; seeing things in the mind's eye)**

Assignment Sheet 1 Determine tire-and-wheel-system service specifications and parts requirements.

- Have students locate Assignment Sheet 1. Read the introduction and directions to the assignment. **(Reading/listening for direction)**

Suggested Activities

- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Listening; reasoning; writing; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

- Answer any student questions and have students complete Assignment Sheet 1.

Job Sheet 1 Service tires and rims.

- Have students locate Job Sheet 1 and the worksheet associated with the job sheet. Demonstrate the procedures for servicing tires and rims. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires service of the tires and rims and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 1.

Job Sheet 2 Service wheel bearings and bushings.

- Have students locate Job Sheet 2 and the worksheet associated with the job sheet. Demonstrate the procedures for servicing wheel bearings and bushings. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires service of wheel bearings and bushings and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 2.

Objective 8 State definitions of the types of brake systems used in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Discuss the purpose of the brake system in terms of slowing, stopping, and holding the vehicle at a stop. Have the students brainstorm the relationship of the engine, transmission, and other drive-train components to these requirements; for example, it may be desirable to disengage the transmission to keep from sending additional power to the wheels or to use the transmission to lock the drive train. Then lead the discussion into ways of using mechanical and hydraulic energy to provide braking capabilities. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

- Provide examples of various types of brake systems. Relate your discussion to clutch systems, in which students have already seen the need for clutches in drive trains and equipment drives. Provide examples of drive-train and equipment-drive brakes that use mechanical, hydraulic, and engine-braking techniques, emphasizing those that are covered in your program. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 9 Match the major components of mechanical brake systems to their correct functions.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 5, "Major Components of Mechanical Brake Systems," to aid in your discussion. **(Reading/listening for content)**

- Provide actual equipment. Display different types of each component, such as brake pedals and hand levers; chain, cable, and rod linkages; internal and external drums; shoes, pads, and external bands; wheel, axles, traction wheels, and other braking surfaces. Discuss combination brake/clutch systems. Help the students relate the various designs to the basic configuration shown in the information sheet. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 10 Match types of mechanical brake systems to their correct descriptions.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparencies 6 through 8 to aid your discussion. **(Reading/listening for content)**

- Provide actual equipment. Demonstrate the design and operation of each type of mechanical brake system. Point out similarities and differences. Discuss the advantages and disadvantages of each in specific applications and describe common applications of each type. Relate these variations to the previous objective as types of friction surfaces. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 11 Complete statements about the principles of operation of mechanical brake systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Build on the previous two objectives by discussing and demonstrating the operation of mechanical brake systems. Point out adjustment mechanisms and discuss the problems that can result from improperly adjusted brakes, such as poor braking and dragging brakes. Point out other potential defects, such as out-of-round drums, worn pads, weak springs, bent rods, etc. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

Objective 12 List typical service procedures required for mechanical brake systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Build on the previous objective by demonstrating and discussing service procedures for mechanical brake systems. Allow students to practice manipulative skills, such as removing springs, adjusting rod lengths, measuring drum diameters, and other procedures related to the job sheets in this unit. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 13 Match the major components of hydraulic brake systems to the correct functions.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 9, "Major Components of Hydraulic Brake Systems," to aid your discussion. **(Reading/listening for content)**
- Provide actual equipment. Discuss sources of hydraulic force, such as self-contained hydraulic brake systems and hydrostatic engine braking. Relate the components of a hydraulic system to those of a mechanical system, showing similarities and contrasts. Display various designs to show different types of actuators, reservoirs, wheel cylinders, braking surfaces, etc. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 14 Complete statements about the principles of operation of hydraulic brake systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Demonstrate the operation of various types of hydraulic brake systems. Discuss the role of components in the operation of the system. Discuss common applications of each type of design and advantages and disadvantages of each for specific applications. Also compare hydraulic systems to mechanical systems in terms of advantages and disadvantages for specific applications. Give an overview of related service procedures. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 15 Distinguish among descriptions of types of disc- and drum-brake hydraulic-cylinder designs.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Provide actual equipment. Discuss sources of hydraulic force, such as self-contained hydraulic brake systems and hydrostatic drive braking. Relate the components of a hydraulic system to those of a mechanical system; show similarities and contrasts. Display various designs to show different types of actuators, reservoirs, wheel cylinders, braking surfaces, etc. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

Objective 16 List typical service procedures required for hydraulic brake systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Pick up on your discussion from the previous objective to go into more detail about service procedures associated with hydraulic brake systems. Relate these procedures to those covered previously for mechanical brake systems. Display wall charts related to the service procedures. Point out comparable procedures for different types of hydraulic brake systems. Emphasize those procedures that will be covered in your presentation of the job sheets and perform relevant demonstrations. Tailor the procedures to the type of equipment and tools available in your facility. Allow students to practice the manipulative skills associated with these procedures. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Objective 17 State safety rules for performing brake-system repair.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Review safety precautions covered in the previous objectives to define safety rules applicable to the inspection and maintenance of brake systems. Point out that brake safety applies not only to the service technician but also to post-service operators because of the role of brakes in operator safety. Review first-aid procedures and locations of first-aid resources that are likely to be required for accidents involving brake service procedures. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 18 Label types of parking brakes used in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparencies 10 and 11 to aid your discussion. **(Reading/listening for content)**

- Provide actual equipment. Include a variety of parking-brake designs and actuation methods. Demonstrate the operation of each type of system. Discuss the components involved. Point out components that are common to both the service and parking brake systems and those that are exclusive to the parking-brake system. Mention service procedures such as lubrication points, adjustments, inspecting linkages and springs, etc., in preparation for the next objective.

Objective 19 List typical service procedures required for parking brakes.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

Suggested Activities

- Pick up on your discussion from the previous objective to go into more detail about service procedures associated with parking brakes. Relate these procedures to those covered previously for mechanical and hydraulic brakes. Display wall charts related to the service procedures. Emphasize those procedures that will be covered in your presentation of the job sheets and perform relevant demonstrations. Tailor the procedures to the type of equipment and tools available in your facility. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Assignment Sheet 2 Determine brake-system service specifications and parts requirements.

- Have students locate Assignment Sheet 2. Read the introduction and directions to the assignment. **(Reading/listening for direction)**
- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Listening; reasoning; writing; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**
- Answer any student questions and have students complete Assignment Sheet 2.

Job Sheet 3 Perform routine maintenance on mechanical brakes.

- Have students locate Job Sheet 3 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on mechanical brake systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment that requires routine maintenance of the mechanical brake system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 3.

Job Sheet 4 Repair mechanical brakes.

- Have students locate Job Sheet 4 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing mechanical brake systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment that requires repair of the mechanical brake system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 4.

Suggested Activities

Job Sheet 5 Perform routine maintenance on hydraulic brake systems.

- Have students locate Job Sheet 5 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on hydraulic brake systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the hydraulic brake system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 5.

Job Sheet 6 Repair hydraulic brakes.

- Have students locate Job Sheet 6 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing hydraulic brake systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the hydraulic brake system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 6.

Job Sheet 7 Perform routine maintenance on parking brakes.

- Have students locate Job Sheet 7 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on parking-brake systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the parking-brake system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 7.

Job Sheet 8 Repair parking brakes.

- Have students locate Job Sheet 8 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing parking-brake systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the parking-brake system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 8.

Suggested Activities

Evaluation

- Evaluate the assignment sheets. See the evaluation criteria listed at the top of each assignment sheet as well as the teacher page "Answers to Assignment Sheets."

- Evaluate the job sheets.

  When the student is ready to perform a specific task, obtain a copy of the worksheet associated with each job sheet. Worksheets may be found in the student edition and in the teacher pages following the transparency masters. Then, observe the student performing the procedure.

  After the student has completed the procedure, rate the student using the criteria provided on the worksheet. If the student's performance is unacceptable, have the student review the materials and perform the procedure again for evaluation.

  Two sample performance evaluation keys are provided below. Many other keys are available. Select one evaluation key (grading scale) that best fits your program needs.

Performance Evaluation Keys

Sample A

4 — Skilled—Can perform job with no additional training.
3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
1 — Unskilled—Is familiar with process, but is unable to perform job.

Sample B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

- Give the written test. See the teacher page "Written Test."

- Evaluate the written test. See the teacher page "Answers to Written Test."

- Compile written-test, assignment-sheet, and job-sheet scores. See the teacher page "Unit Evaluation Form."

- Reteach and retest as required.

Suggested resources

Resources used in developing this unit

Print media

- Graf, Rudolf F., and George J. Whalen. *VNR Illustrated Guide to Power Tools*. New York: Van Nostrand Reinhold Company, 1978.
- Hawker, M. F. J., and J. F. Keenlyside. *Horticultural Machinery*, 3rd ed. Essex, England: Longman Group Limited, 1985.
- Jorgensen, Eric, editor. *Kawasaki 250-750cc Triples*, 5th ed. Arleta, California: Clymer Publications, 1979.
- *MTD Yard-Man Technical Service Handbook*. Cleveland, Ohio: MTD Products, Inc., 1996.
- *Outdoor Power Equipment Repair*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1985.
- *Power Tools and Equipment*. Alexandria, Virginia: Time-Life Books, Inc., 1989.
- *Power Trains: Compact Equipment*. Moline, Illinois: Deere and Company, 1991.
- *Riding Lawn Mower Service Manual*, 3rd ed. Overland Park, Kansas: Intertec Publishing Corporation, 1989.
- *Small Tractor Service Manual*. Overland Park, Kansas: Intertec Publishing Corporation, 1984.
- Wright, Ron. *Harley-Davidson Sportsters*, 7th ed. Arleta, California: Clymer Publications, 1986.
- *Yard and Garden Tractor Service Manual*, 1st ed. Overland Park, Kansas: Intertec Publishing Corporation, 1992.

Suggested supplemental resources

Print media

- *Outdoor Power Equipment* magazine. Adams/Green Industry Publishing, 68860 Perez Road, Suite J, Cathedral City, California 92234. Web site: http://www.outdoorpowerequipment.com
- *Power Equipment Trade* magazine. Hatton-Brown Publishers, Inc., P. O. Box 2268, Montgomery, Alabama 36102.
- *Technical Handbook*. Describes the makes and types of equipment produced by MTD—one of the nation's largest manufacturers. The book covers service for most equipment systems and various types of equipment. Both light- and heavy-duty equipment types are included. Available from MTD Products, Inc. Call 1-800-422-3381.
- Service manuals for systems covered in this unit.

Suggested Activities

- Parts catalogs for systems covered in this unit. Available from equipment manufacturers.

Non-print media

- *Brakes*. International Film Bureau, Inc., 332 S. Michigan Avenue, Chicago, Illinois 60604-4382, (312) 427-4545.

Wheel and Brake Systems
Unit 5

Answers to Assignment Sheets

Assignment Sheet 1—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1. a. Answer depends on references used.
   b. Answer depends on references used.
   c. Answer depends on references used.

2. a. 8 psi
   b. 10 to 12 psi
   c. 12 psi

3. a. SAE 30 engine oil
   b. Snapper 00 grease
   c. Chassis grease
   d. Multipurpose lithium-based grease
   e. SAE 30 engine oil

4. a. Snap ring
   b. Retaining ring
   c. Lug bolts
   d. Bolts through hub
   e. Bolt through axle

Assignment Sheet 2—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1. a. 0.010 to 0.015 inch
   b. By turning the nut labeled "1" in the illustration

2. a. Disengage the drive clutch and depress the brake pedal. Try to push the mower. If the rear wheels rotate, release the brake and turn the cam-lever adjusting nut one-half turn. Repeat the procedure as required until the wheels do not turn.

   b. Install the adjusting pin with the rounded end toward the cam lever

3. a. Answer depends on references used.
   b. Answer depends on references used.
   c. 1.5 inches

Answers to Assignment Sheets

4. a. The transmission shifts to neutral.
   b. A mechanical disc brake is applied.
   c. ⅞ inch
   d. ⅜ to ¾ inch
   e. Adjusting nut

5. a. 2
   b. By engaging the parking-brake arm
   c. 22
   d. With the adjusting screw tightened one-half turn beyond when the wheels skid with the parking brake engaged
   e. 24

Wheel and Brake Systems
Unit 5

Answers to Written Test

1. a. Supports the equipment and provides traction for self-propelled equipment
   b. Holds air under pressure
   c. Provides the means for inserting air into the tube or tire
   d. Supports the tire and provides a seal for tubeless pneumatic tires
   e. Provides the mechanism for mounting the tire and wheel assembly to the axle
   f. Fasten the tire and wheel assembly to the axle

2. a. 5
   b. 2
   c. 4
   d. 3
   e. 1

3. Answers may appear in any order.

   - Split
   - Solid
   - Spoked

4. Answers may appear in any order.

   - Bearings
   - Bushings

5. Answers should include any four of the following.

   - Remove and replace wheel assembly
   - Remove and replace tire
   - Repair inner tube
   - Repair tubeless tire
   - Replace valve stem
   - Lubricate wheel bearings or bushings
   - Remove and replace wheel bearings or bushings

6. a. 5
   b. 8
   c. 10
   d. 9
   e. 2
   f. 11
   g. 4
   h. 7
   i. 1
   j. 6
   k. 3

7. a. Never overinflate tires or tubes.
   b. Exhaust the air from tires before demounting.
   c. Do not apply heat to inflated tires or tubes.
   d. Ensure that the vehicle cannot fall or roll when raised for service.

Answers to Written Test

e. Ensure that tire and rim sizes match.
f. Do not attempt to repair damaged rims; replace them.
g. Before installing a tire, inspect it for damage and defects.
h. Do not use tubes that are buckled, creased, or misshapened.
i. Ensure that the tube and the tire sizes match.
j. Ensure that a tube is centered and properly seated in a tire before inflating the tube.
k. Do not install a tube in a tubeless tire.
l. Do not stand over a tire while inflating it.

8. a. Brake system that uses mechanical means to allow the operator to apply pressure to the wheels to slow or stop equipment movement
b. Brake system that uses special hydraulic fluid in a closed system to assist in the application of pressure to the wheels to slow or stop equipment movement
c. Brake system that uses torque from the engine to slow or stop equipment movement

9. a. 5
b. 2
c. 4
d. 3
e. 1

10. a. 3
b. 1
c. 2

11. a. lever
b. chain; cable; linkages; wheels; axles
c. wheel; axle
d. springs; mechanisms; wheel; axle

12. Answers should include any four of the following.

- Adjust linkages
- Lubricate actuating mechanism
- Replace friction surfaces
- Refinish braking surface
- Replace linkages
- Replace braking surface

13. a. 6
b. 1
c. 7
d. 5
e. 4
f. 3
g. 2

Answers to Written Test

14. a. cylinder
    b. hydraulic fluid
    c. pistons; cylinders
    d. shoe; pad; drum; disc
    e. slowly; stop
    f. springs
    g. equalized

15. a. AB
    b. BA
    c. BB
    d. AA

16. Answers should include any seven of the following.

- Adjust linkages
- Lubricate actuating mechanism
- Replace friction surfaces
- Refinish braking surface
- Replace linkages
- Replace braking surface
- Adjust fluid level
- Bleed brake system
- Flush brake system
- Repair system leaks
- Replace hydraulic hoses

17. a. Use proper procedures for handling, repairing, and disposing of brake components that contain or may contain asbestos.
    b. Avoid getting brake fluids in your eyes and mouth; follow label instructions for first aid in the event of an accident.
    c. Use care in handling brake-system springs, which can break or fly off their fasteners and present flying-object dangers.
    d. Keep fingers and other body parts clear of braking mechanisms that may be actuated.
    e. Do not contaminate friction surfaces or braking surfaces with oils, grease, or other contaminants that can reduce braking effectiveness.

18. a. Independent actuator
    b. Mechanical lock

19. Answers may appear in any order.

- Adjust actuating mechanism
- Replace actuating-mechanism components
- Free frozen actuator parts

Wheel and Brake Systems
Unit 5

Written Test

Name ________________________________ Score ______________

1. State the functions of the major components of tire and wheel assemblies. Write your answers on the blanks provided beside each of the components listed below.

   a. Tire ____

   ____

   b. Tube ____

   ____

   c. Valve stem ____

   ____

   d. Rim ____

   ____

   e. Hub ____

   ____

   f. Fasteners ____

   ____

2. Match types of tires used in power product equipment to their correct descriptions. Write the numbers on the blanks provided.

   _______ a. Tire that is usually made of solid rubber or hard plastic and, when mounted, seats completely on the wheel

   _______ b. Tire that is filled with air through a valve stem and, when mounted, seats along the wheel rim

   _______ c. Tire that is filled with air and vented to the outside atmosphere but has no valve stem and, when mounted, seats completely on the wheel

   _______ d. Tire that has a thick outside and a small, hollow inside in which air is trapped and, when mounted, seats completely on the wheel

   _______ e. Tire that is made of a hard-rubber outer covering with an inner core of softer rubber and, when mounted, seats completely on the wheel

   1. Foam filled
   2. Pneumatic
   3. Low pressure
   4. Semi-pneumatic
   5. Solid

Written Test

3. List types of rims used in tire and wheel assemblies. Write your answers on the blanks provided.

   a. ________________________________

   b. ________________________________

   c. ________________________________

4. List types of wheel supports used in tire and wheel assemblies. Write your answers on the blanks provided.

   a. ________________________________

   b. ________________________________

5. List four of the typical service procedures required for tire and wheel assemblies. Write your answers on the blanks provided.

   a. ________________________________

   b. ________________________________

   c. ________________________________

   d. ________________________________

6. Match specialty tools used in tire and wheel service to their correct uses. Write the numbers on the blanks provided.

________ a. Used to separate tube and tubeless tires and other types of tires from rims and to separate wheels from axles

________ b. Used to measure air pressure in tubes and tires

________ c. Used to measure tire wear

________ d. Used to mount and demount tires

________ e. Used to return spoked rims to true alignment after spoke replacement

________ f. Used to remove stems, repair stem threads, and extract broken cores

________ g. Used to remove tires from rims

________ h. Used to pry tires from rims

________ i. Used to break the seal between tubeless tires and rims

________ j. Used to apply pressure to the sidewall of a tire by clamping on the rim to separate the tire from the rim

________ k. Used to apply pressure to the crown of a tire to improve the seal between the tire and the rim when mounting a tire

1. Bead breaker
2. Truing stand
3. Bead expander
4. Tire-changing machine
5. General-purpose hammers
6. Portable bead breaker
7. Swan-neck bead tool
8. Tire-pressure gauge
9. Tire spoons
10. Tire-tread-depth gauge
11. Tire-valve repair tool

Written Test

7. State safety rules for performing tire and wheel service. Write the complete safety rule on the blanks provided beside each of the terms below.

   a. Overinflating ______________________________

   ____

   b. Exhausting air ______________________________

   ____

   c. Applying heat ______________________________

   ____

   d. Raising vehicle for service ______________________________

   ____

   e. Tire and rim sizes ______________________________

   ____

   f. Repairing rims ______________________________

   ____

   g. Inspecting tires ______________________________

   ____

   h. Misshapened tubes ______________________________

   ____

   i. Tire and tube sizes ______________________________

   ____

   j. Centering tube ______________________________

   ____

   k. Tubeless tire ______________________________

   ____

   l. Standing over a tire ______________________________

   ____

Written Test

8. State definitions of the types of brake systems used in power product equipment. Write your answers on the blanks provided beside each of the terms below.

   a. Mechanical ______________________________
   ____
   ____

   b. Hydraulic ______________________________
   ____
   ____

   c. Engine braking ______________________________
   ____
   ____

9. Match the major components of mechanical brake systems to their correct functions. Write the numbers on the blanks provided.

   _______ a. Causes the friction surface to move away from the braking surface when the actuator is released

   _______ b. Fastens to the wheel or drive mechanism so that application of the brake will cause the wheel or mechanism to slow

   _______ c. Connects the actuator to the friction surface

   _______ d. Applies pressure to the braking surface

   _______ e. Allows the operator to apply the brakes

   1. Actuator
   2. Braking surface
   3. Friction surface
   4. Linkage
   5. Return mechanism

10. Match types of mechanical brake systems to their correct descriptions. Write the numbers on the blanks provided.

    _______ a. System in which actuating the brake causes a friction band to tighten around a drum mounted on a drive axle

    _______ b. System in which actuating the brake causes a caliper device to squeeze a disc on a portion of the drive train, such as a chain-drive sprocket

    _______ c. System in which actuating the brake causes one or more shoes to press against the inside of a drum mounted on a drive axle

    1. Disc
    2. Drum
    3. External band

Written Test

11. Complete statements about the principles of operation of mechanical brake systems. Write the missing word(s) on the blanks provided in the statements below.

    a. The operator actuates a pedal or ____________________.

    b. The actuator is connected to a ____________________ or ____________________ or to ____________________ that allow movement of the braking mechanism—such as a shoe, pad, or band—to apply friction to one or more ____________________ or ____________________.

    c. The friction applied to the ____________________ or ____________________ causes it to turn more slowly and eventually to stop if friction continues to be applied.

    d. When the actuator is released, ____________________ or other ____________________ move the friction surfaces away from the braking surface so that friction on the ____________________ or ____________________ is reduced and the wheel is free to turn.

12. List four of the typical service procedures required for mechanical brake systems. Write your answers on the blanks provided.

    a. ____

    b. ____

    c. ____

    d. ____

13. Match the major components of hydraulic brake systems to their correct functions. Write the numbers on the blanks provided.

    ________ a. Breaks the contact between the friction surface and the braking surface when the brake actuator is released

    ________ b. Allows the operator to apply or release the brakes by moving the primary piston to force fluid through the system

    ________ c. House the piston that responds to pressure from the primary piston to apply the brakes

    ________ d. Stores the fluid for use in the brake system and houses the primary piston

    ________ e. Carry the fluid through the system

    ________ f. Makes contact with the moving component to cause it to slow or stop

    ________ g. Provides the contact area for the friction surface

    1. Brake lever
    2. Braking surface
    3. Friction surface
    4. Lines
    5. Master cylinder
    6. Return mechanism
    7. Wheel cylinders

Written Test

14. Complete statements about the principles of operation of hydraulic brake systems. Write the missing word(s) on the blanks provided in the statements below.

    a. Actuating a lever or pedal causes a piston in a hydraulic __________________ to move.

    b. The movement of the piston applies pressure to the __________________, which transmits force through the system.

    c. System pressure causes the __________________ at one or more wheels to move in their __________________.

    d. The wheel-cylinder pistons are connected to a friction surface, such as a __________________ or __________________, and this movement causes the friction surface to contact a braking surface, such as a __________________ or __________________, that is mounted to the wheel or drive axle.

    e. The friction applied to the wheel causes it to turn more __________________ and eventually to __________________ if friction continues to be applied.

    f. When the actuator is released, __________________ or other mechanisms move the friction surfaces away from the braking surface so that friction on the wheel or axle is reduced and the wheel is free to turn.

    g. The pistons in the hydraulic system return to their normal positions and system pressure is __________________.

15. Distinguish among descriptions of types of disc- and drum-brake hydraulic-cylinder designs. Write an "AA" before the description of a disc-brake system with a fixed caliper; write an "AB" before the description of a disc-brake system with a floating caliper; write a "BA" before the description of a single-piston wheel-cylinder drum-brake system; and write a "BB" before the description of a dual-piston wheel-cylinder drum-brake system.

_______ a. Hydraulic fluid flows into the caliper and pushes one piston against the rotor with the caliper sliding a short distance so that a fixed brake pad also contacts the rotor

_______ b. Hydraulic fluid flows into the cylinder to push the piston, which in turn pushes the shoes into contact with the drum

_______ c. Hydraulic fluid flows into the cylinder and pushes outward on two pistons, each of which pushes a shoe into contact with the drum

_______ d. Hydraulic fluid flows into the caliper and pushes two pistons—one from each side—into contact with the rotor

Written Test

16. List seven of the typical service procedures required for hydraulic brake systems. Write your answers on the blanks provided.

    a. ______________________________

    b. ______________________________

    c. ______________________________

    d. ______________________________

    e. ______________________________

    f. ______________________________

    g. ______________________________

17. State safety rules for performing brake-system repair. Write the complete safety rules on the blanks provided beside each of the terms below.

    a. Asbestos ______________________________

    ____

    b. Brake fluid ______________________________

    ____

    c. Springs ______________________________

    ____

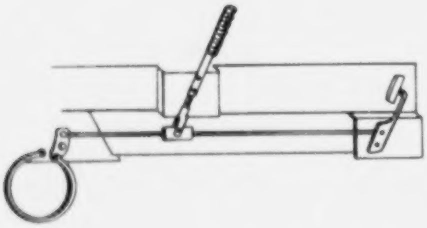
    d. Braking mechanisms ______________________________

    ____

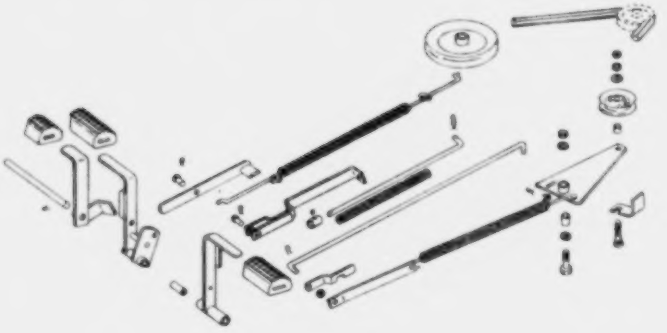
    e. Contaminants ______________________________

    ____

18. Label types of parking brakes used in power product equipment. Write your answers on the blanks provided under each of the illustrations below.



a. ______________________________



b. ______________________________

Drawing in Test-item 18-b reproduced by permission of Deere & Company. Copyright 1993. All rights reserved, Deere & Company, Moline, Illinois.

19. List typical service procedures required for parking brakes. Write your answers on the blanks provided.

   a. ______________________________

   b. ______________________________

   c. ______________________________

Permission to duplicate this test is granted.

Wheel and Brake Systems
Unit 5

Unit Evaluation Form

Student name ____________________ Unit rating ____________

Assignment-sheet ratings

Assignment Sheet 1—Determine Tire-and-Wheel-System Service Specifications and Parts Requirements Rating ________

Comments: ____________________

____

Assignment Sheet 2—Determine Brake-System Service Specifications and Parts Requirements Rating ________

Comments: ____________________

____

Job-sheet ratings

Job Sheet 1—Service Tires and Rims Rating ________

Comments: ____________________

____

Job Sheet 2—Service Wheel Bearings and Bushings Rating ________

Comments: ____________________

____

Job Sheet 3—Perform Routine Maintenance on Mechanical Brakes Rating ________

Comments: ____________________

____

Job Sheet 4—Repair Mechanical Brakes Rating ________

Comments: ____________________

____

Unit Evaluation Form

Job Sheet 5—Perform Routine Maintenance on Hydraulic Brakes Rating ________

Comments: ____

____

Job Sheet 6—Repair Hydraulic Brakes Rating ________

Comments: ____

____

Job Sheet 7—Perform Routine Maintenance on Parking Brakes Rating ________

Comments: ____

____

Job Sheet 8—Repair Parking Brakes Rating ________

Comments: ____

____

Written-test scores

Pretest ________ Posttest ________ Other ________

Comments: ____

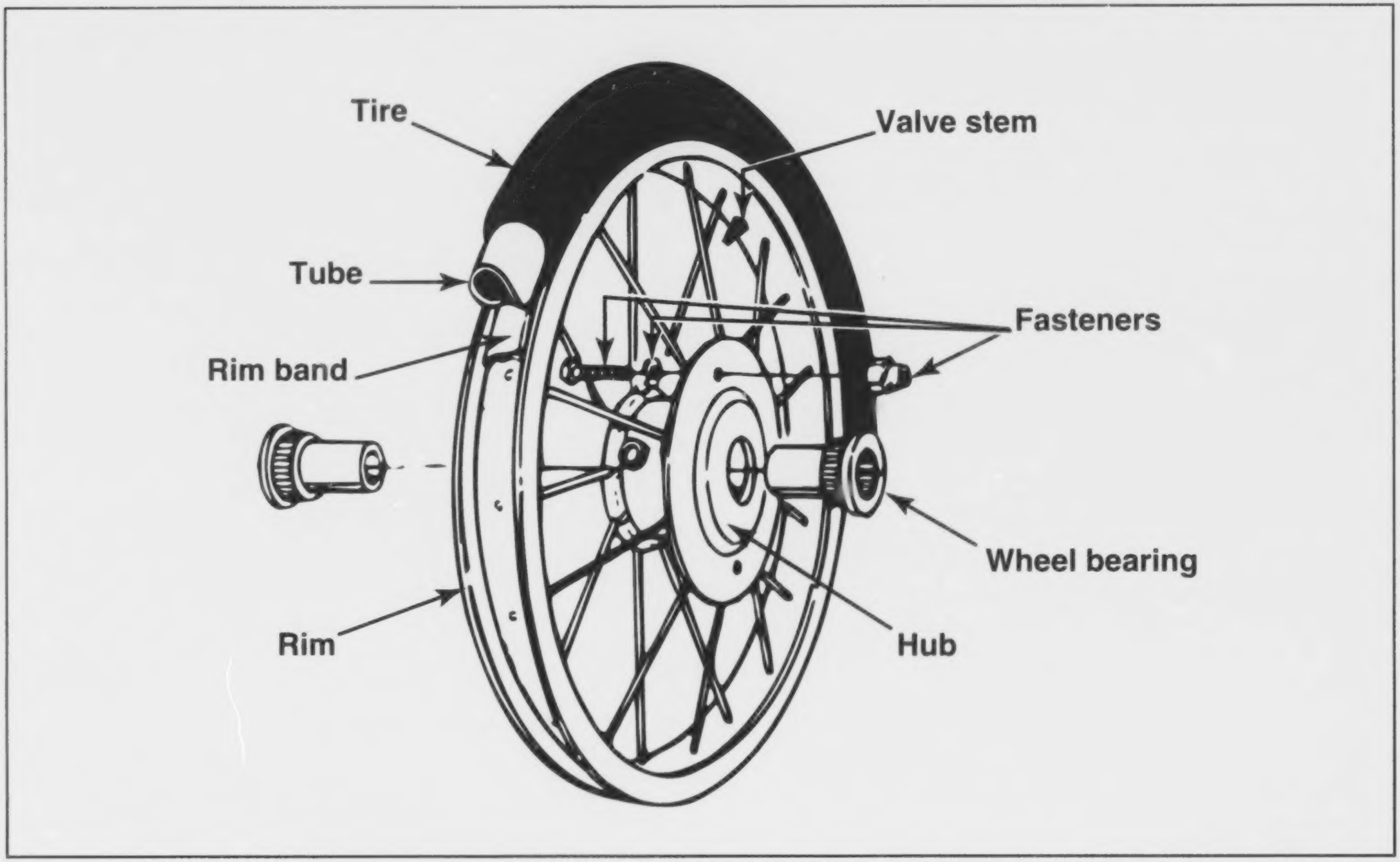
____

Teacher signature ______________________ Date ____________

Student signature ______________________ Date ____________

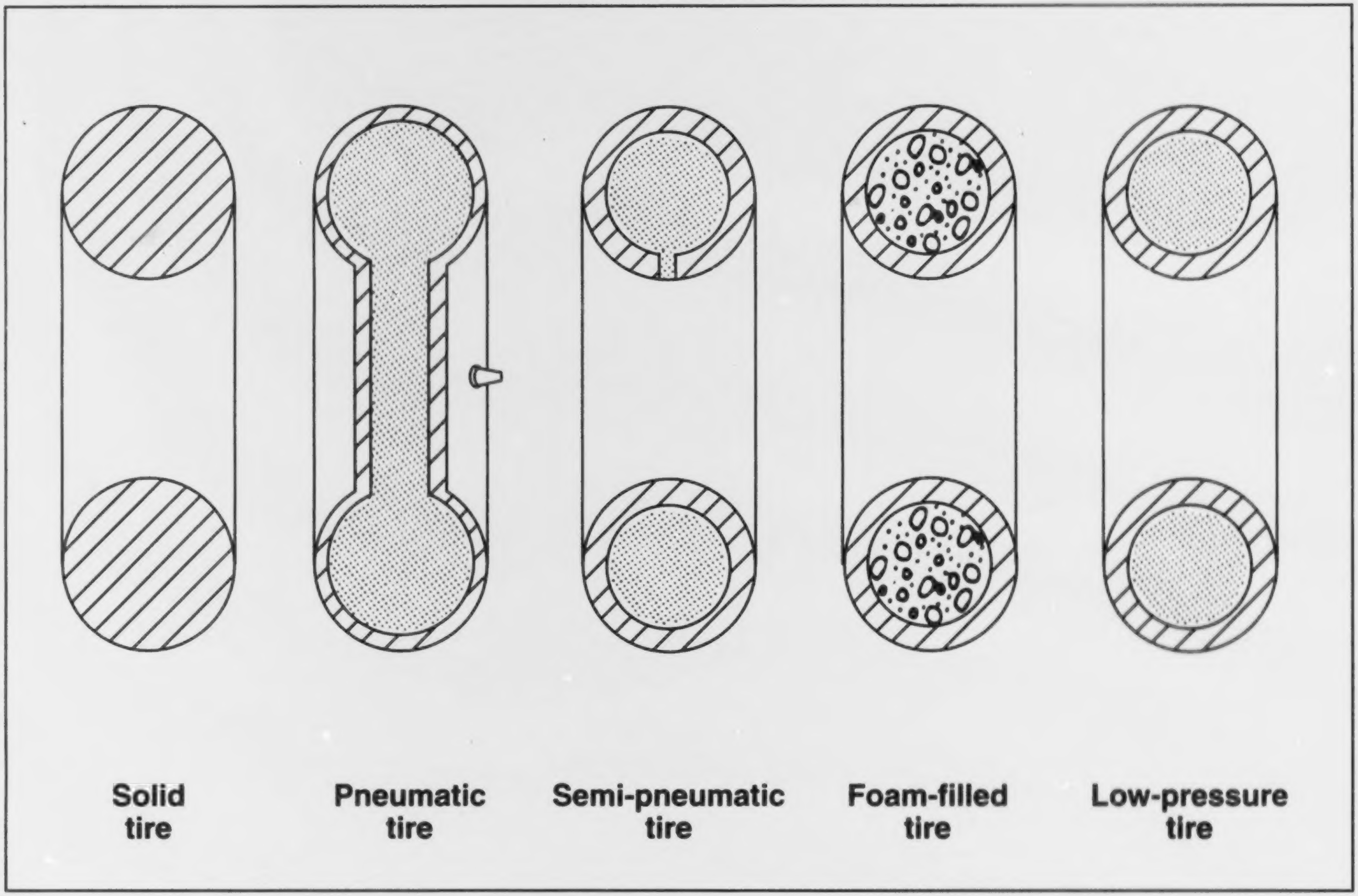
Permission to duplicate this form is granted.

Major Components of Tire and Wheel Assemblies


Tire
Valve stem
Tube
Fasteners
Rim band
Wheel bearing
Rim
Hub

Drawing reproduced by permission of Mike Barnett, MTD Products, Inc., Cleveland, Ohio.

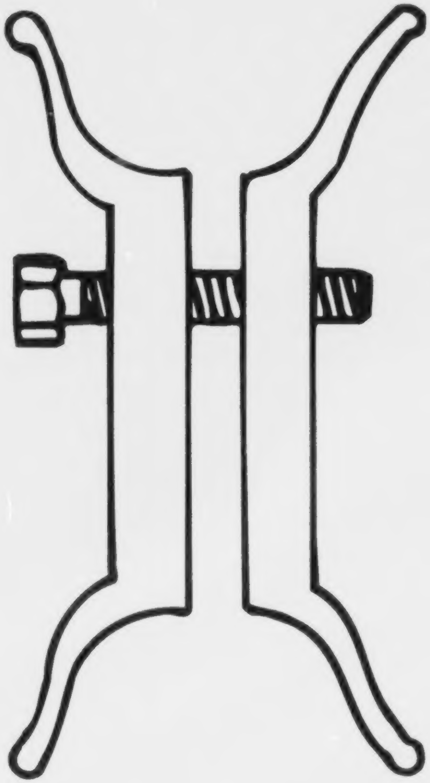
Types of Tires


Solid tire
Pneumatic tire
Semi-pneumatic tire
Foam-filled tire
Low-pressure tire

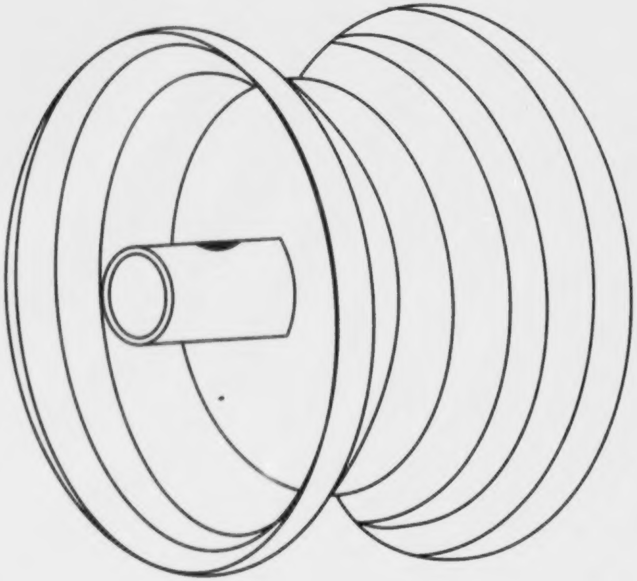
Equipment Systems, Unit 5
Teacher Page 275

TM 2

Types of Rims

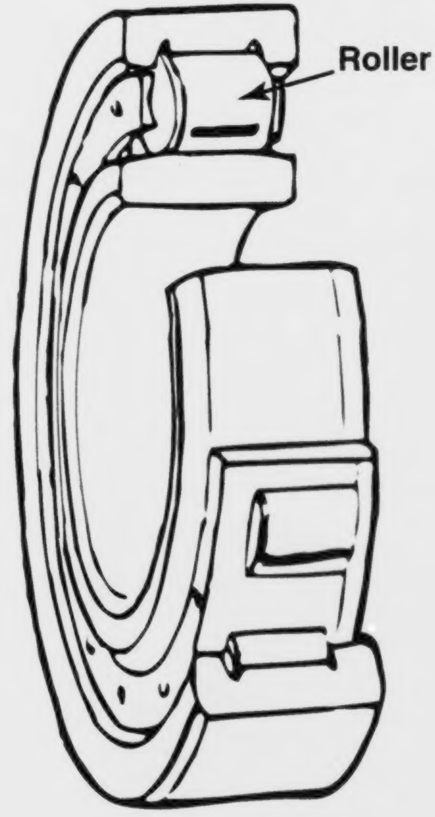


Split rim

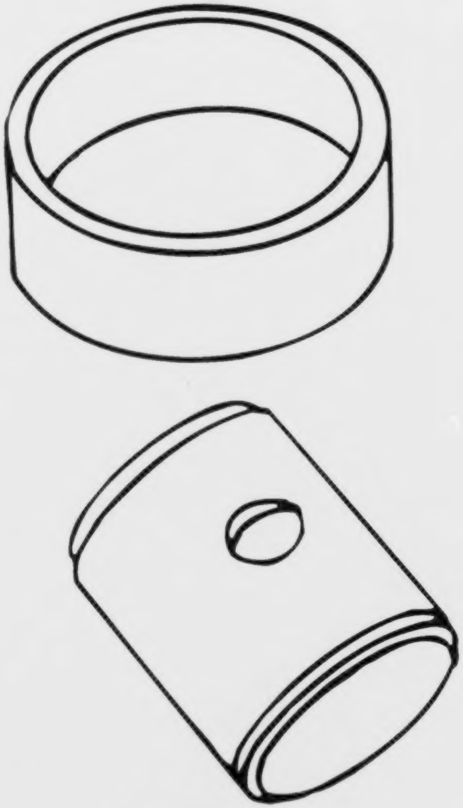


Solid rim

Types of Wheel Supports

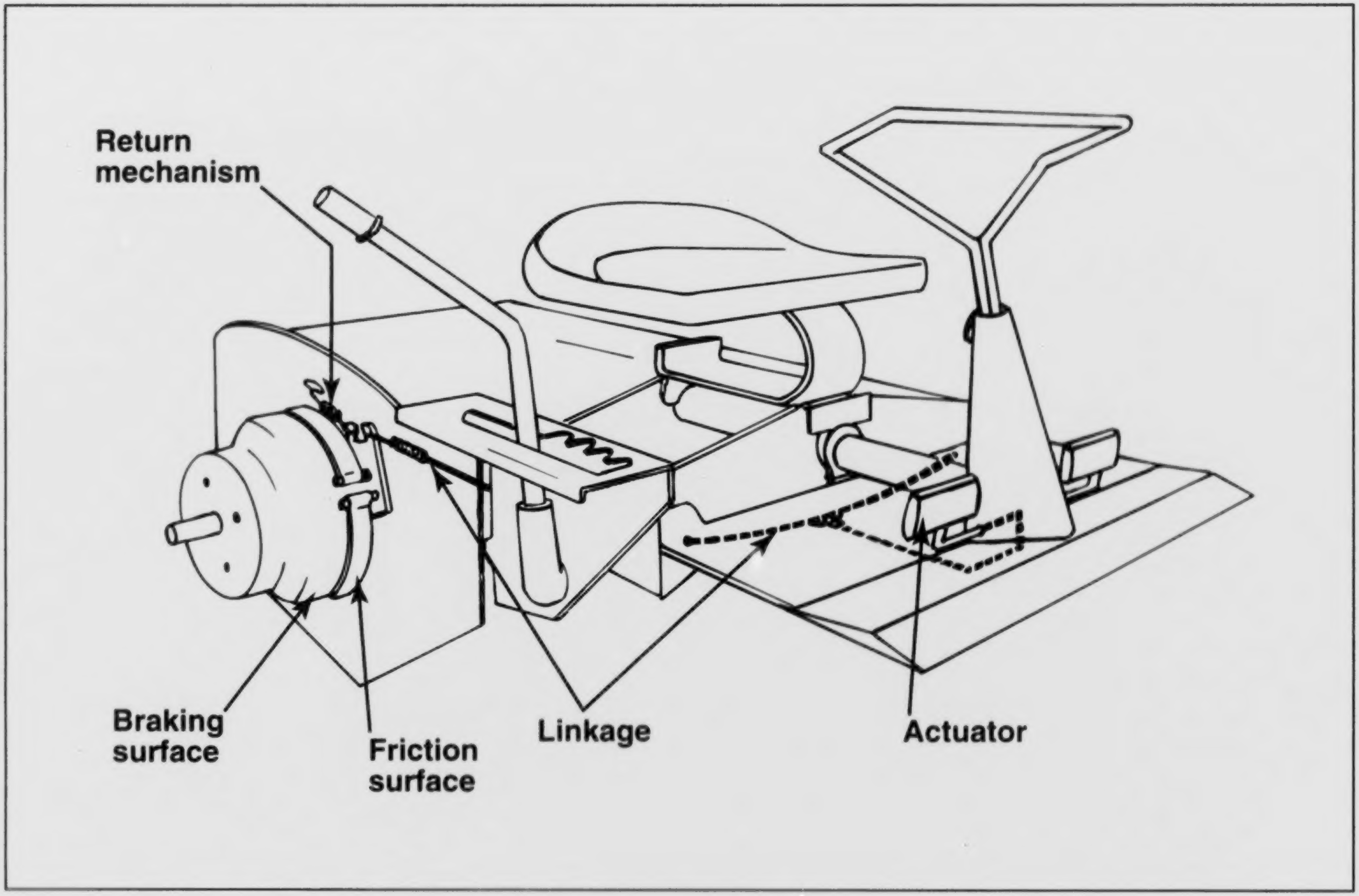


Roller bearing



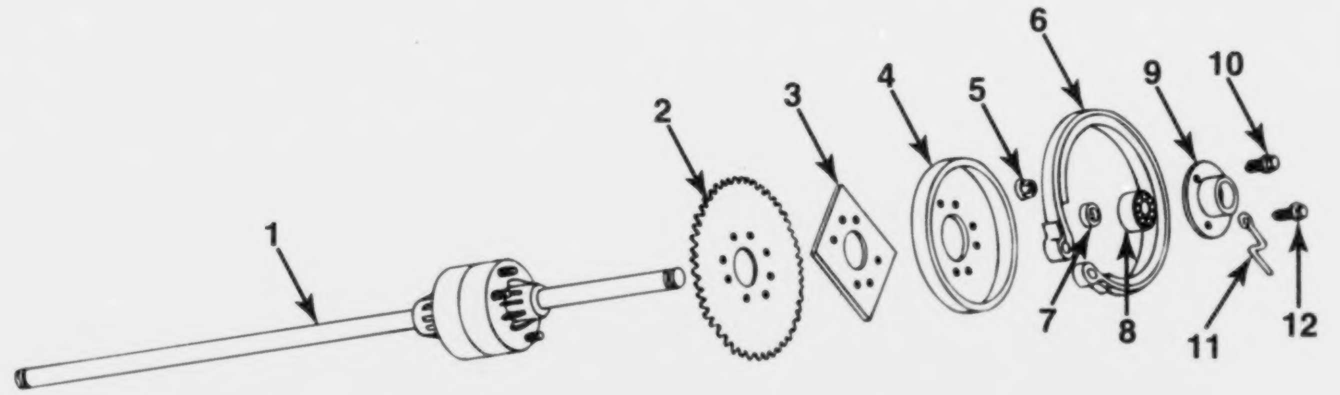
Bushings

Major Components of Mechanical Brake Systems


Return mechanism
Braking surface
Friction surface
Linkage
Actuator

Types of Mechanical Brake Systems:

External Band



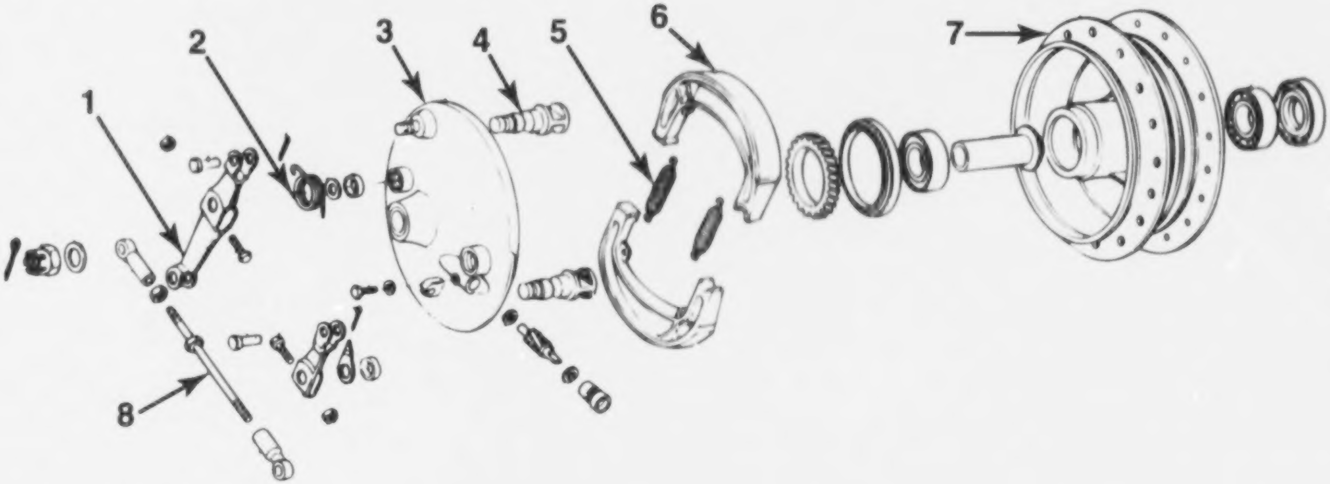
1. Differential and axle assembly
2. Sprocket
3. Plate
4. Brake drum
5. Nut
6. Brake band
7. Spacer
8. Bearing
9. Bearing carrier
10. Screw
11. Brake-band stop
12. Screw

Drawing reproduced by permission of Simplicity Manufacturing, Inc., Port Washington, Wisconsin.

TM 6

Types of Mechanical Brake Systems:

Drum



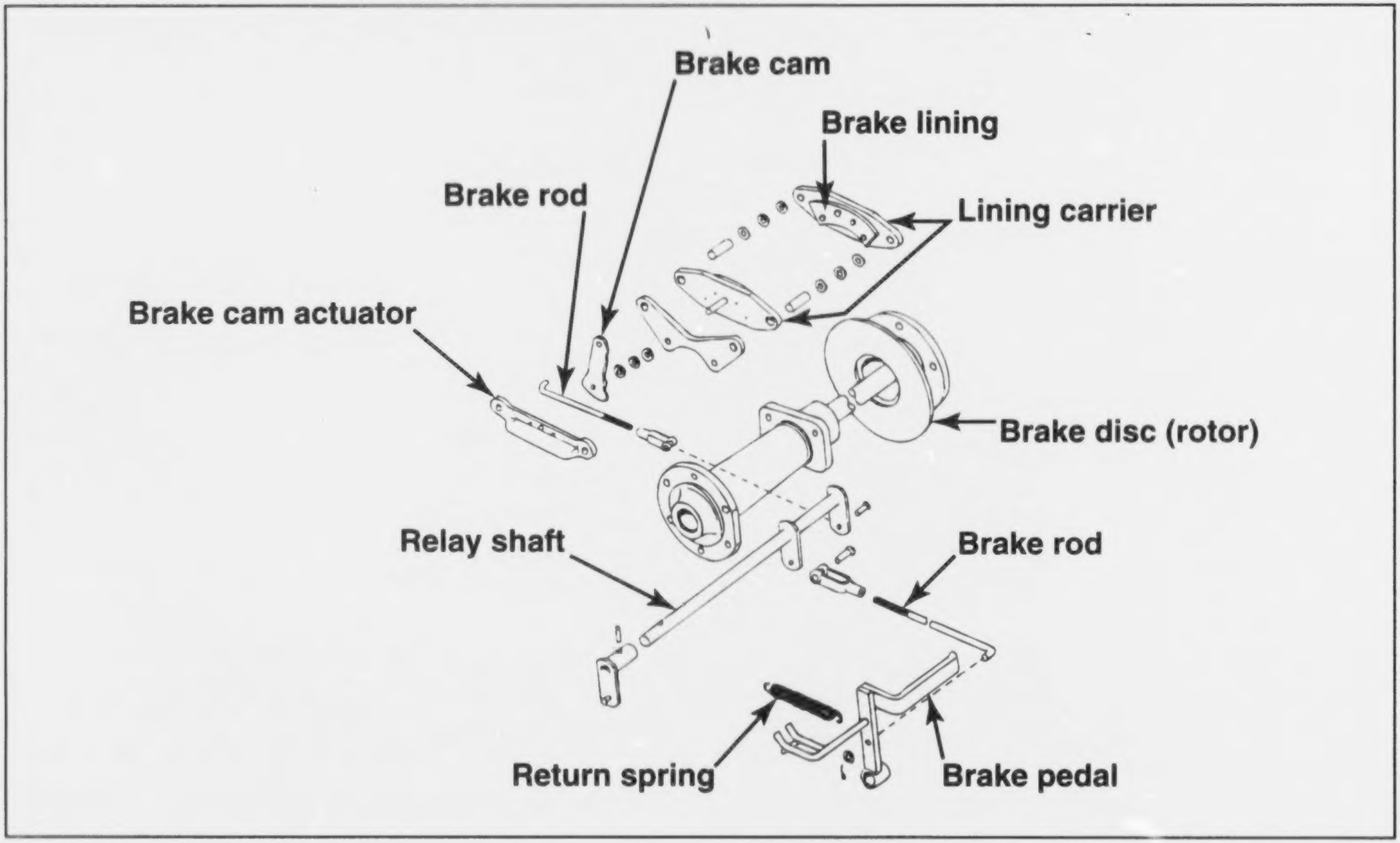
1. **Cam lever**
2. **Return spring**
3. **Brake panel**
4. **Camshaft**
5. **Shoe spring**
6. **Brake shoe**
7. **Front hub**
8. **Connecting rod**

TM 7

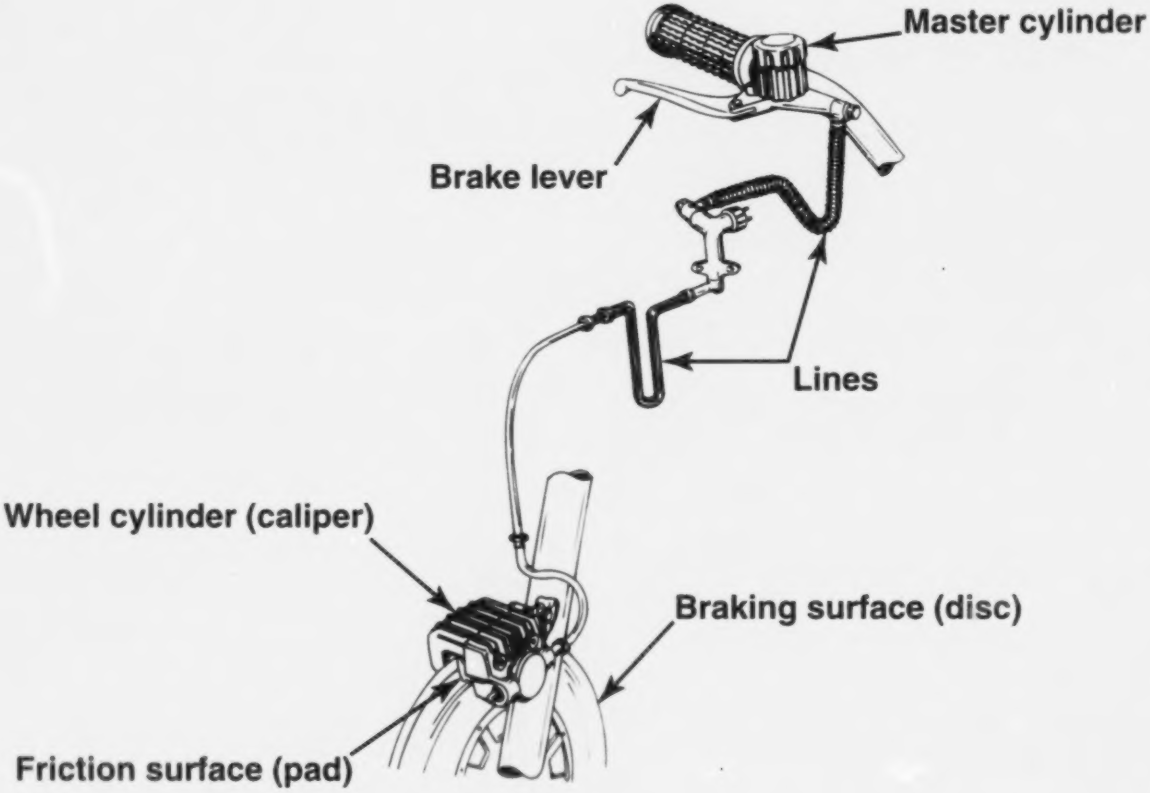
Drawing reproduced by permission of Kawasaki Motors Corporation U.S.A., Irvine, California.

Types of Mechanical Brake Systems:

Disc

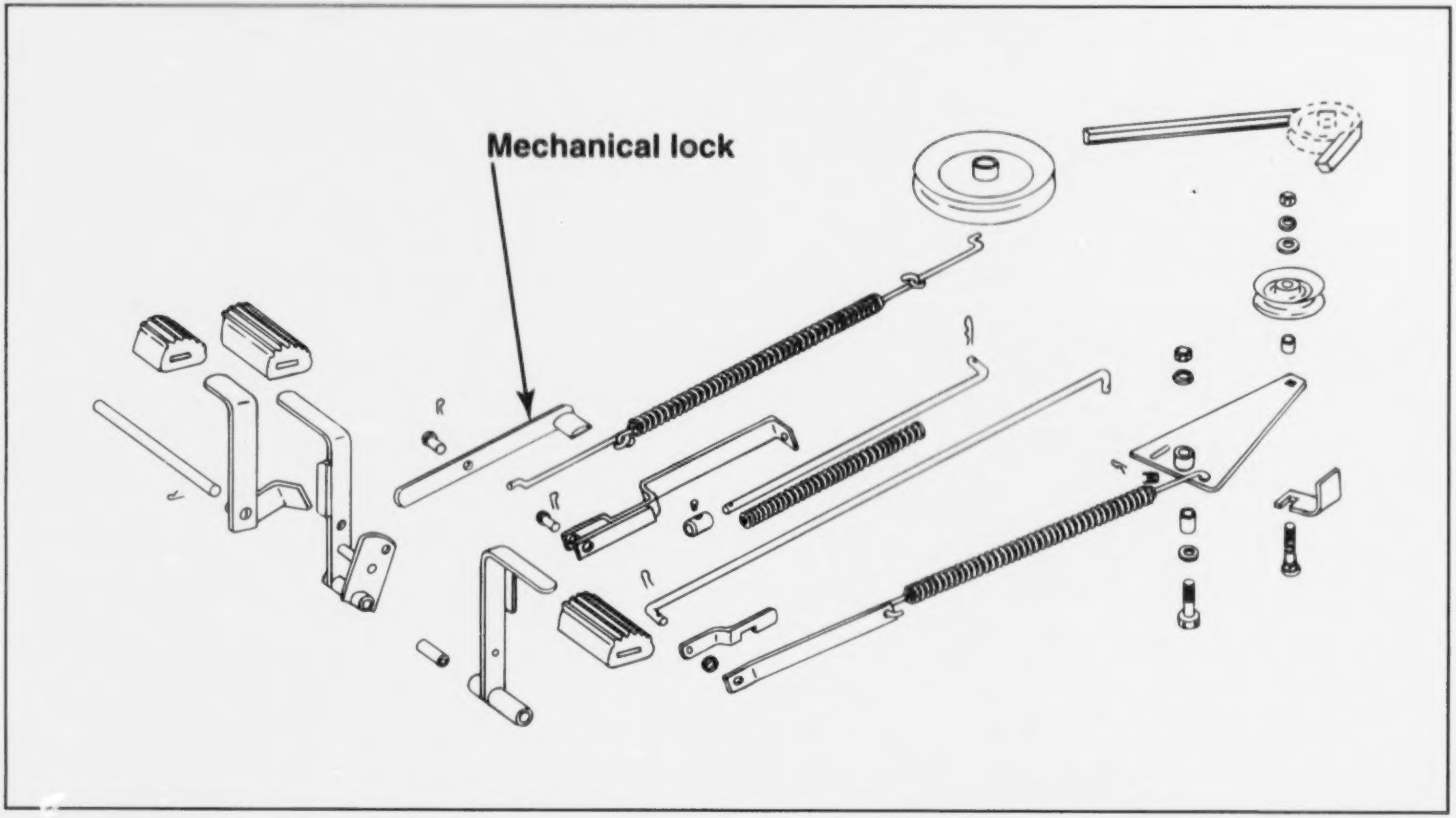

Brake cam
Brake lining
Brake rod
Lining carrier
Brake cam actuator
Brake disc (rotor)
Relay shaft
Brake rod
Return spring
Brake pedal

Major Components of Hydraulic Brake Systems


Master cylinder
Brake lever
Lines
Wheel cylinder (caliper)
Braking surface (disc)
Friction surface (pad)

Types of Parking Brakes:

Mechanical Lock



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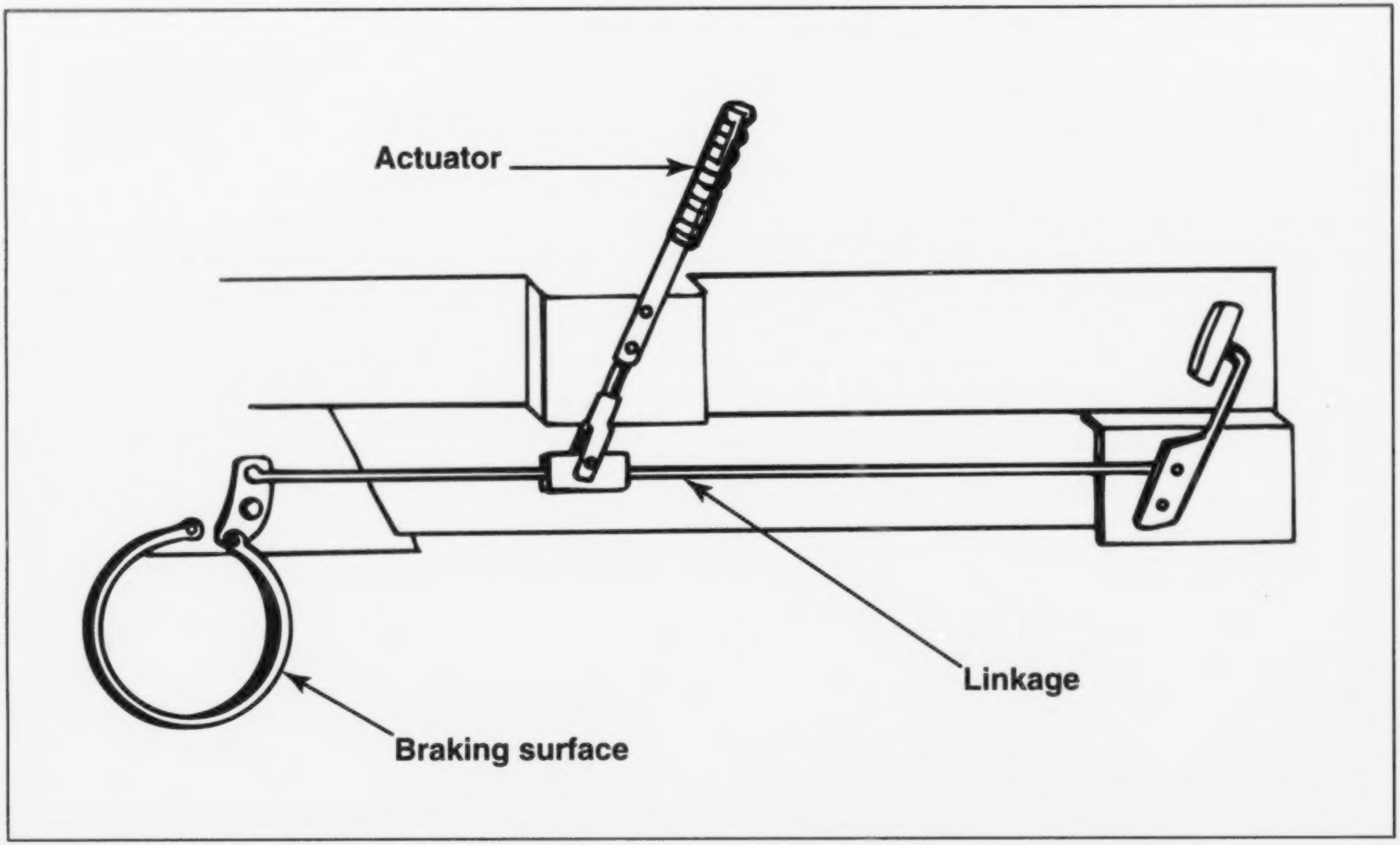
Equipment Systems, Unit 5
Teacher Page 291

TM 10

Types of Parking Brakes:

Independent Actuator


Actuator
Linkage
Braking surface

Equipment Systems, Unit 5
Teacher Page 293

TM 11

Job Sheet 1

Worksheet—Service Tires and Rims

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Worksheet—Service Tires and Rims

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 2

Worksheet—Service Wheel Bearings and Bushings

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 2

Worksheet—Service Wheel Bearings and Bushings

Part B: Performance evaluation

Evaluation criteria **Rating**

Correct procedures identified for assigned equipment. ______

Procedures completed correctly. ______

Proper tools used correctly. ______

Safety precautions observed. ______

Service meets specifications. ______

Clean-up and follow-up actions adequate. ______

Overall rating ______

Evaluator's comments ____

____

____

Job Sheet 3

Worksheet—Perform Routine Maintenance on Mechanical Brakes

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

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Instructor's signature ______________________

Job Sheet 3

Worksheet—Perform Routine Maintenance on Mechanical Brakes

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 4

Worksheet—Repair Mechanical Brakes

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 4

Worksheet—Repair Mechanical Brakes

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 5

Worksheet—Perform Routine Maintenance on Hydraulic Brakes

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ____

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 5

Worksheet—Perform Routine Maintenance on Hydraulic Brakes

Part B: Performance evaluation

Evaluation criteria	Rating
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 6

Worksheet—Repair Hydraulic Brakes

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 6

Worksheet—Repair Hydraulic Brakes

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Worksheet—Perform Routine Maintenance on Parking Brakes

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 7

Worksheet—Perform Routine Maintenance on Parking Brakes

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 8

Worksheet—Repair Parking Brakes

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Worksheet—Repair Parking Brakes

Part B: Performance evaluation

Evaluation criteria	Rating
Correct procedures identified for assigned equipment.	
Procedures completed correctly.	
Proper tools used correctly.	
Safety precautions observed.	
Service meets specifications.	
Clean-up and follow-up actions adequate.	
Overall rating	

Evaluator's comments ______________________________

____

____

Chassis and Steering Systems
Unit 6

Suggested Activities

Instructional plan

Preparation

- Review the unit in the student edition and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Plan presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare the classroom by displaying posters, equipment, and tools related to chassis and steering systems.
- Make transparencies from the transparency masters included in the teacher pages of this unit.
- Select teacher components (written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution.
- Review the job sheets in the student edition and locate the worksheet masters included in the teacher pages of this unit. Copy and prepare extra worksheets for distribution to your students.

Delivery and application

Unit introduction

The skill areas appearing in bold-face type in the unit introduction and teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want.* These have been adapted by MAVCC.

- Provide the students with the student materials. You may choose to begin by discussing the objective sheet. Review the unit and specific objectives with the students. Discuss how meeting the unit objective will improve students' employability or will increase their value as an employee. Explain how the specific objectives support the unit objective. **(Reading; listening; adapting to the organization's traditional modes of operation)**

Suggested Activities

- Introduce the unit by reviewing the systems that the students have studied to this point. Talk about how those systems are tied together and supported by the chassis. Display several pieces of equipment, including riding lawn mowers, garden tractors, motorcycles, snowmobiles, and tillers and other equipment with chassis and frame parts. Point out differences and similarities and the role of the chassis and frame in supporting parts, operational controls, and connecting parts. **(Listening; seeing things in the mind's eye; system interrelationships)**

Teaching suggestions

Objective 1 Match the major components of chassis to their correct functions.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 1, "Major Components of Chassis," to aid the discussion. **(Reading/listening for content)**
- Show examples of chassis components and provide actual examples of equipment with chassis. Discuss how the equipment is assembled and the role of the components in the functioning of the equipment. Show a variety of designs—those that are primarily frames, those that provide a seat for an operator, those with different types of wheel and axle configurations, etc.—and point out the corresponding components in the various chassis designs. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 2 List typical service procedures required for chassis.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Demonstrate the service procedures outlined in the information sheet. Stress the importance of each procedure in protecting the equipment and allowing the equipment to continue functioning. Display examples of rusted and corroded equipment and equipment that has worn or failed because the operator has neglected to maintain fasteners and proper alignment. Discuss manufacturers' recommendations for cleaning and protecting chassis components. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 3 List types of steering systems used in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Provide equipment that uses a variety of steering-system types. Point out the major components of mechanical, hydraulic, and drive-wheel systems, emphasizing similarities and differences. Relate the steering-system types to their advantages and disadvantages in specific applications. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

Objective 4 List types of steering-system configurations used in power product equipment.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 2, "Types of Steering-System Configurations," to aid the discussion. **(Reading/listening for content)**
- During your discussion of steering-system types and designs, it is likely that you may have displayed more than one configuration of steering platform. Discuss those now. Relate the types and designs to the various configurations. Discuss advantages and disadvantages of front-wheel, rear-wheel, and four-wheel configurations for specific applications. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 5 State the functions of the major components of steering systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 3, "Major Components of Steering Systems," to aid the discussion. **(Reading/listening for content)**
- Using the preceding objectives as a spring board, get into more detail about the components and operation of steering systems. Discuss the function of each component and variations in their designs. Discuss malfunctions of the steering system and service requirements. Show the students examples of systems with adjustable alignment and those with nonadjustable alignment. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 6 Describe the principles of operation of types of gears used in steering systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparencies 4 through 6 to aid the discussion. **(Reading/listening for content)**
- Provide actual equipment to discuss types of steering gears. Demonstrate how each type of gear operates. Discuss advantages and disadvantages of each type in specific applications. Discuss service requirements for each type, such as lubrication and adjustment requirements. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 7 List typical service procedures required for steering systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Expand your discussion of service procedures begun in the previous unit by demonstrating the listed service procedures. Discuss and display the associated tools and service equipment. Have the students practice the manipulative skills associated with the listed service procedures, such as lubricating steering gears, pulling steering columns, adjusting and measuring toe-in, etc. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

Assignment Sheet 1 Determine chassis and steering-system service specifications and parts requirements.

- Have students locate Assignment Sheet 1. Read the introduction and directions to the assignment. **(Reading/listening for direction)**

- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Listening; reasoning; writing; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

- Answer any student questions and have students complete Assignment Sheet 1.

Job Sheet 1 Repair or replace chassis components.

- Have students locate Job Sheet 1 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing or replacing chassis components. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair or replacement of chassis components and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 1.

Job Sheet 2 Perform routine maintenance on mechanical steering systems.

- Have students locate Job Sheet 2 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on a mechanical steering system. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the mechanical steering system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 2.

Job Sheet 3 Repair mechanical steering systems.

- Have students locate Job Sheet 3 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing a mechanical steering system. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

Suggested Activities

- Provide students with power product equipment that requires repair of the mechanical steering system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 3.

Job Sheet 4 Perform routine maintenance on hydraulic steering systems.

- Have students locate Job Sheet 4 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on a hydraulic steering system. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the hydraulic steering system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 4.

Job Sheet 5 Repair hydraulic steering systems.

- Have students locate Job Sheet 5 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing a hydraulic steering system. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the hydraulic steering system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 5.

Job Sheet 6 Perform routine maintenance on drive-wheel steering systems.

- Have students locate Job Sheet 6 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on a drive-wheel steering system. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the drive-wheel steering system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 6.

Suggested Activities

Job Sheet 7 Repair drive-wheel steering systems.

- Have students locate Job Sheet 7 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing a drive-wheel steering system. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the drive-wheel steering system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 7.

Evaluation

- Evaluate the assignment sheet. See the evaluation criteria listed at the top of the assignment sheet as well as the teacher page "Answers to Assignment Sheet."

- Evaluate the job sheets.

When the student is ready to perform a specific task, obtain a copy of the worksheet associated with each job sheet. Worksheets may be found in the student edition and in the teacher pages following the transparency masters. Then, observe the student performing the procedure.

After the student has completed the procedure, rate the student using the criteria provided on the worksheet. If the student's performance is unacceptable, have the student review the materials and perform the procedure again for evaluation.

Two sample performance evaluation keys are provided below. Many other keys are available. Select one evaluation key (grading scale) that best fits your program needs.

Performance Evaluation Keys

Sample A

4 — Skilled—Can perform job with no additional training.
3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
1 — Unskilled—Is familiar with process, but is unable to perform job.

Sample B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

Suggested Activities

- Give the written test. See the teacher page "Written Test."
- Evaluate the written test. See the teacher page "Answers to Written Test."
- Compile written-test, assignment-sheet, and job-sheet scores. See the teacher page "Unit Evaluation Form."
- Reteach and retest as required.

Suggested resources

Resources used in developing this unit

Print media

- Graf, Rudolf F., and George J. Whalen. *VNR Illustrated Guide to Power Tools.* New York: Van Nostrand Reinhold Company, 1978.
- Hawker, M. F. J., and J. F. Keenlyside. *Horticultural Machinery,* 3rd ed. Essex, England: Longman Group Limited, 1985.
- Jorgensen, Eric, editor. *Kawasaki 250-750cc Triples,* 5th ed. Arleta, California: Clymer Publications, 1979.
- *MTD Yard-Man Technical Service Handbook.* Cleveland, Ohio: MTD Products, Inc., 1996.
- *Outdoor Power Equipment Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1985.
- *Power Tools and Equipment.* Alexandria, Virginia: Time-Life Books, Inc., 1989.
- *Power Trains: Compact Equipment.* Moline, Illinois: Deere and Company, 1991.
- *Riding Lawn Mower Service Manual,* 3rd ed. Overland Park, Kansas: Intertec Publishing Corporation, 1989.
- *Small Tractor Service Manual.* Overland Park, Kansas: Intertec Publishing Corporation, 1984.
- Wright, Ron. *Harley-Davidson Sportsters,* 7th ed. Arleta, California: Clymer Publications, 1986.
- *Yard and Garden Tractor Service Manual,* 1st ed. Overland Park, Kansas: Intertec Publishing Corporation, 1992.

Suggested supplemental resources

Print media

- *Outdoor Power Equipment* magazine. Adams/Green Industry Publishing, 68860 Perez Road, Suite J, Cathedral City, California 92234. Web site: http://www.outdoorpowerequipment.com

Suggested Activities

- *Power Equipment Trade* magazine. Hatton-Brown Publishers, Inc., P. O. Box 2268, Montgomery, Alabama 36102.
- *Technical Handbook*. Describes the makes and types of equipment produced by MTD—one of the nation's largest manufacturers. The book covers service for most equipment systems and various types of equipment. Both light- and heavy-duty equipment types are included. Available from MTD Products, Inc. Call 1-800-422-3381.
- Service manuals for systems covered in this unit.
- Parts catalogs for systems covered in this unit. Available from equipment manufacturers.

Chassis and Steering Systems
Unit 6

Answers to Assignment Sheet

Assignment Sheet 1—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1. a. 19
   b. Under
   c. Bracket (11)
   d. a

2. "A" should be ⅛ to ⅜ inch less than "B."

3. To allow hydraulic oil to flow so that the equipment can be moved

4. a. SAE 30 engine oil
   b. John Deere Multipurpose Lubricant No. TY2098
   c. No. 2 multipurpose lithium grease
   d. SAE 30 engine oil
   e. Multipurpose grease

5. a. $9\frac{1}{32}$ inches (229.5 mm)
   b. $10\frac{15}{16}$ inches (277.8 mm)
   c. 16 inches (406.5 mm)
   d. $19\frac{15}{16}$ inches (506.5 mm)
   e. 30 to 35 ft-lbs. (40-48 N•m)

Chassis and Steering Systems
Unit 6

Answers to Written Test

1. a. 6 d. 5 g. 7
   b. 2 e. 3
   c. 1 f. 4

2. Answer should include any three of the following.

- Clean chassis components
- Inspect fasteners
- Lubricate moving parts
- Refinish chassis to prevent rust and corrosion
- Maintain component alignment

3. Answers may appear in any order.

- Mechanical
- Hydraulic
- Drive wheel

4. Answers may appear in any order.

- Front-wheel steering
- Rear-wheel steering
- Four-wheel steering

5. a. Provides a means for the operator to control the left and right direction of travel
   b. Transmits force from the steering handle to the steering mechanism
   c. Transmits force from the steering shaft to the steering gear
   d. Converts the rotary motion of the steering shaft into lateral motion
   e. Provides the support for the axle components
   f. Allows the main member to swivel to accommodate changes in the driving surface
   g. Pivots to change the direction of the steerable wheels
   h. Provides a reduced-friction surface against which the spindle can pivot
   i. Transmits force from the steering gear to the pivot point of the steerable wheels; connects the left and right spindles and provides a method for adjusting the distance between the spindles to set the alignment of the steerable wheels
   j. Connects the tie rod and spindles with ball joints so that the movement of the steering axle accommodates changes in the driving surface

6. a. The end of the steering shaft consists of a worm gear; the steering linkage includes an output shaft with a pin that rides in the worm gear so that the shaft rotates as the worm gear turns.

   b. The end of the steering shaft consists of a pinion gear; the steering linkage is attached to a semicircular or quarter-circle gear that is rotated by the pinion gear.

Answers to Written Test

c. The end of the steering shaft provides an attachment to the axle, either directly or through a drag link, so that rotation of the steering shaft causes the wheel or wheels to pivot.

d. The end of the steering shaft is a pinion gear; the steering linkage is a flat, toothed bar called a *rack* that moves laterally as the steering shaft is rotated and attached to the axles so that the wheels pivot as the rack moves.

e. The end of the steering shaft is a sprocket; a chain connects the steering sprocket to an output sprocket that is attached to the steering axle or wheels.

7. Answers should include any five of the following.

- Align steering system, including toe-in
- Align system components
- Lubricate moving parts
- Remove and replace steering gear
- Adjust linkages
- Adjust hydraulic and hydrostatic steering-belt tension
- Replace belts and chains
- Check and refill hydraulic-fluid reservoirs

Chassis and Steering Systems
Unit 6

Written Test

Name ______________________________ Score ______________

1. Match the major components of chassis to their correct functions. Write the numbers on the blanks provided.

_______ a. Protects the top and sides of the engine from dust, dirt, water, flying objects, and other debris, while also permitting the flow of cooling air

_______ b. Provides the rigid foundation to which the engine, chassis components, wheel system, and other systems are mounted

_______ c. Supports the shroud and protects the engine while allowing cooling air to enter the front of the equipment

_______ d. Supports the rider

_______ e. Supports the tread and provides a degree of lateral strength to the equipment

_______ f. Allows the equipment to be set up on its end or raised by the rear

_______ g. Provides the step the operator uses to board the equipment

1. Cap
2. Frame
3. Plate
4. Rear stand
5. Seat assembly
6. Shroud
7. Tread

2. List three of the typical service procedures required for chassis. Write your answers on the blanks provided.

a. ______________________________

b. ______________________________

c. ______________________________

3. List types of steering systems used in power product equipment. Write your answers on the blanks provided.

a. ______________________________

b. ______________________________

c. ______________________________

Written Test

4. List types of steering-system configurations used in power product equipment. Write your answers on the blanks provided.

   a. ______________________________

   b. ______________________________

   c. ______________________________

5. State the functions of the major components of steering systems. Write your answers on the blanks provided beside each of the components listed below.

   a. Steering handle ______________________________

   b. Steering shaft ______________________________

   c. Steering-shaft linkage ______________________________

   d. Steering gear ______________________________

   e. Main member ______________________________

   f. Pivot pin ______________________________

   g. Spindle ______________________________

   h. Spindle bearing ______________________________

   i. Tie rod ______________________________

   j. Tie-rod end ______________________________

Written Test

6. Describe the principles of operation of the types of gears used in steering systems. Write your answers on the blanks provided beside each of the types of gears listed below.

   a. Worm and pin ______________________________

   ____

   ____

   b. Quadrant gear ______________________________

   ____

   ____

   c. Direct link ______________________________

   ____

   ____

   d. Rack and pinion ______________________________

   ____

   ____

   e. Chain and sprocket ______________________________

   ____

   ____

7. List five of the typical service procedures required for steering systems. Write your answers on the blanks provided.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

   e. ______________________________

Permission to duplicate this test is granted.

Chassis and Steering Systems
Unit 6

Unit Evaluation Form

Student name ______________________________ Unit rating ______________

Assignment-sheet rating

Assignment Sheet 1—Determine Chassis and Steering-System Service Specifications and Parts Requirements Rating ________

Comments: ______________________________

____

Job-sheet ratings

Job Sheet 1—Repair or Replace Chassis Components Rating ________

Comments: ______________________________

____

Job Sheet 2—Perform Routine Maintenance on Mechanical Steering Systems Rating ________

Comments: ______________________________

____

Job Sheet 3—Repair Mechanical Steering Systems Rating ________

Comments: ______________________________

____

Job Sheet 4—Perform Routine Maintenance on Hydraulic Steering Systems Rating ________

Comments: ______________________________

____

Job Sheet 5—Repair Hydraulic Steering Systems Rating ________

Comments: ______________________________

____

Unit Evaluation Form

Job Sheet 6—Perform Routine Maintenance on Drive-Wheel Steering Systems Rating ______

Comments: ____

____

Job Sheet 7—Repair Drive-Wheel Steering Systems Rating ______

Comments: ____

____

Written-test scores

Pretest ______ Posttest ______ Other ______

Comments: ____

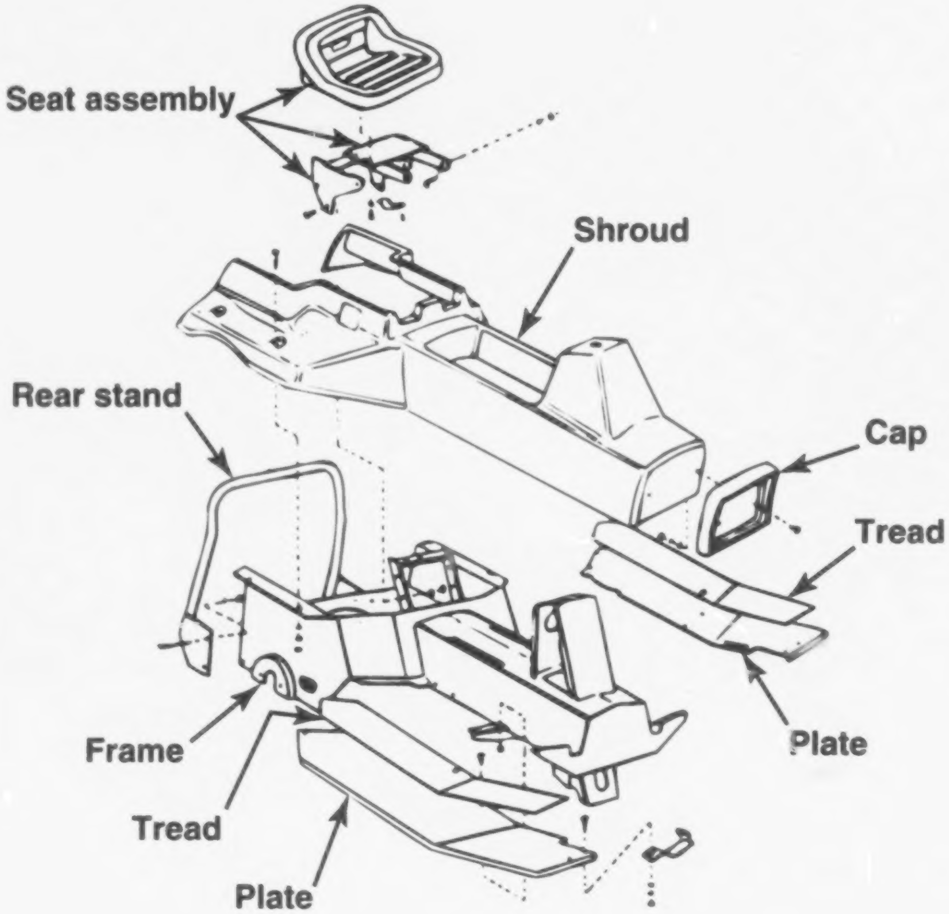
____

Teacher signature ____________________ Date ______

Student signature ____________________ Date ______

Permission to duplicate this form is granted.

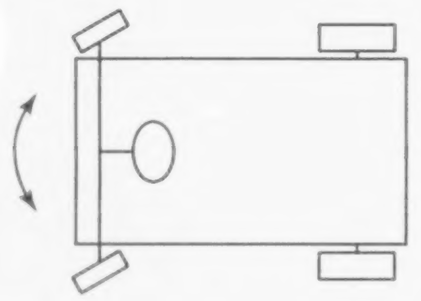
Major Components of Chassis

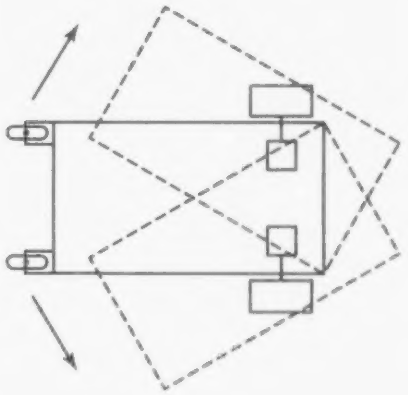

Seat assembly
Shroud
Rear stand
Cap
Tread
Plate
Frame
Tread
Plate

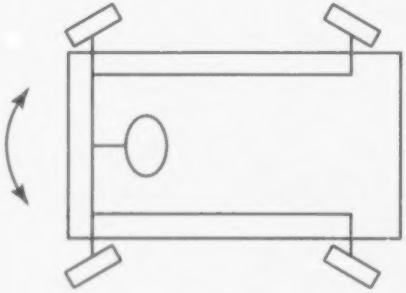
Drawing reproduced by permission of Massey-Ferguson, Inc., Des Moines, Iowa.

TM 1

Types of Steering-System Configurations


Front-wheel steering


Rear-wheel steering


Four-wheel steering

Equipment Systems, Unit 6
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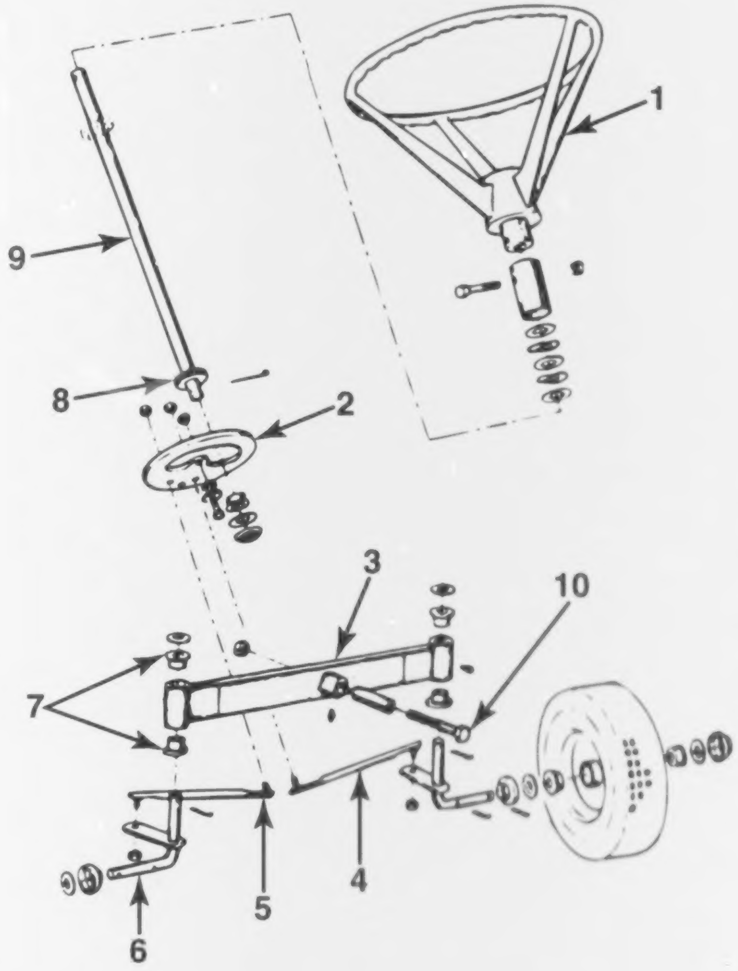
TM 2

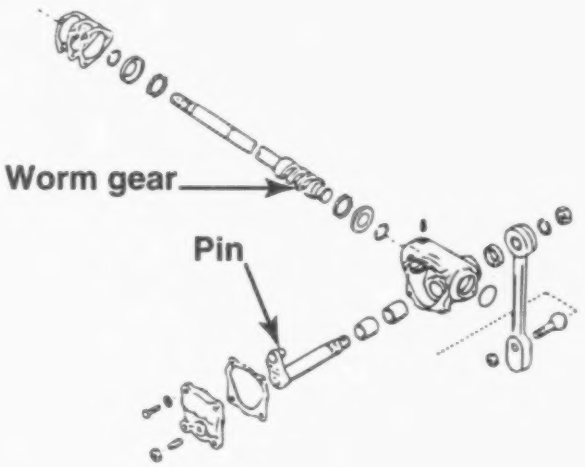
Major Components of Steering Systems



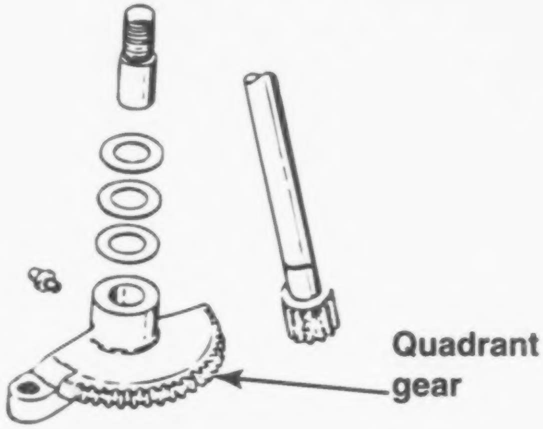
1. Steering handle (steering wheel)
2. Steering gear (quadrant gear)
3. Main member
4. Tie rod (drag link)
5. Tie-rod end (drag-link arm)
6. Spindle (axle)
7. Spindle bearings
8. Steering-shaft linkage (pinion gear)
9. Steering shaft
10. Pivot pin

Drawing reproduced by permission of New Holland North America, Inc., New Holland, Pennsylvania.

Types of Gears Used in Steering Systems

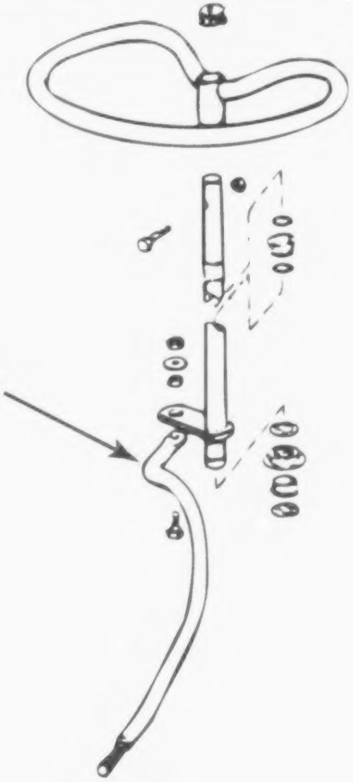

Worm gear
Pin

Worm and pin

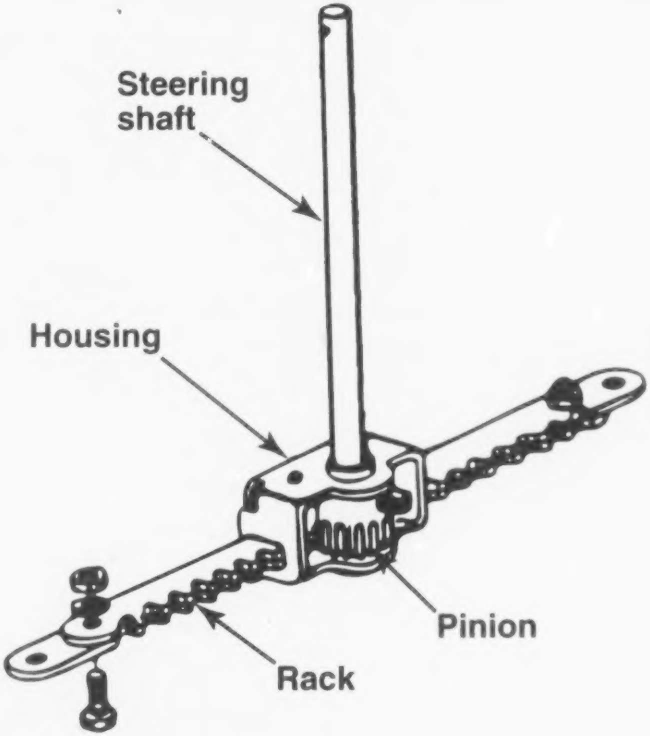

Quadrant gear

Quadrant gear

Types of Gears Used in Steering Systems (cont.)



Direct link


Steering shaft
Housing
Pinion
Rack

Rack and pinion

Rack-and-pinion drawing reproduced by permission of Mike Barnett, MTD Products, Inc., Cleveland, Ohio.

Equipment Systems, Unit 6
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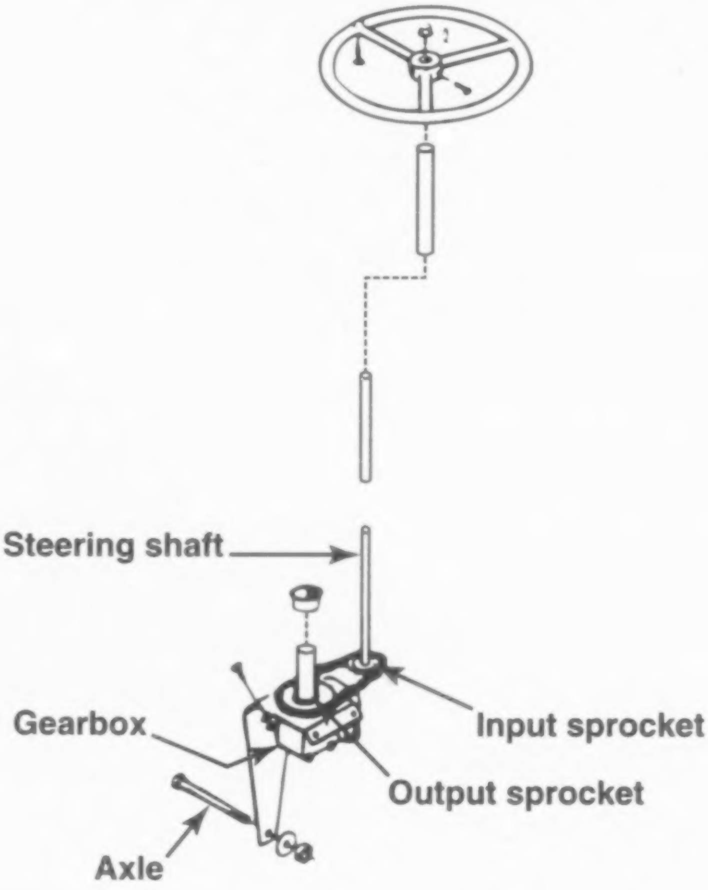
TM 5

Types of Gears Used in Steering Systems (cont.)


Steering shaft
Gearbox
Input sprocket
Output sprocket
Axle

Chain and sprocket

Drawing reproduced by permission of Ride King, Warrensburg, Missouri.

Job Sheet 1

Worksheet—Repair or Replace Chassis Components

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 1

Worksheet—Repair or Replace Chassis Components

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	
Procedures completed correctly.	
Proper tools used correctly.	
Safety precautions observed.	
Service meets specifications.	
Clean-up and follow-up actions adequate.	
Overall rating	

Evaluator's comments ______________________________

Job Sheet 2

Worksheet—Perform Routine Maintenance on Mechanical Steering Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 2

Worksheet—Perform Routine Maintenance on Mechanical Steering Systems

---

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 3

Worksheet—Repair Mechanical Steering Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

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Instructor's signature ______________________

Job Sheet 3

Worksheet—Repair Mechanical Steering Systems

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 4

Worksheet—Perform Routine Maintenance on Hydraulic Steering Systems

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Worksheet—Perform Routine Maintenance on Hydraulic Steering Systems

---

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 5

Worksheet—Repair Hydraulic Steering Systems

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

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Instructor's signature ______________________________

Job Sheet 5

Worksheet—Repair Hydraulic Steering Systems

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 6

Worksheet—Perform Routine Maintenance on Drive-Wheel Steering Systems

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Worksheet—Perform Routine Maintenance on Drive-Wheel Steering Systems

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Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 7

Worksheet—Repair Drive-Wheel Steering Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 7

Worksheet—Repair Drive-Wheel Steering Systems

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	_______
Procedures completed correctly.	_______
Proper tools used correctly.	_______
Safety precautions observed.	_______
Service meets specifications.	_______
Clean-up and follow-up actions adequate.	_______
Overall rating	_______

Evaluator's comments ____

____

____

Chassis Electrical Systems
Unit 7

Suggested Activities

Instructional plan

Preparation

- Review the unit in the student edition and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the unit introduction and teaching suggestions included in the delivery and application section below, and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan presentation to take advantage of student learning styles and to accommodate special-needs students.

- Prepare the classroom by displaying posters, equipment, and tools related to chassis electrical systems.

- Make transparencies from the transparency masters included in the teacher pages of this unit.

- Select teacher components (written test, unit evaluation form) you want to distribute to your students. Copy and prepare these components for distribution.

- Review the job sheets and worksheets in the student edition and locate the worksheet masters included in the teacher pages of this unit. Copy and prepare extra worksheets for distribution to your students.

Delivery and application

Unit introduction

The skill areas appearing in bold-face type in the unit introduction and teaching suggestions refer to the academic and workplace skills identified in *What Work Requires of Schools: A SCANS Report for America 2000* and *Workplace Basics: The Skills Employers Want.* These have been adapted by MAVCC.

- Provide students with the student materials. You may choose to begin by discussing the objective sheet. Review the unit and specific objectives with the students. Discuss how meeting the unit objective will improve their employability or will increase their value as an employee. Explain how the specific objectives support the unit objective. **(Reading; listening; adapting to the organization's traditional modes of operation)**

Suggested Activities

Teaching suggestions

Objective 1 Match terms associated with electrical systems to their correct definitions.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use terms and definitions to review electrical concepts that most students should have studied related to engine electrical systems. Tailor your presentation to the skills of your students. Demonstrate electrical characteristics with a multimeter and continuity light. Point out shutoffs and shields on equipment in your facility. Demonstrate that the engine will not start or that equipment (PTOs, blades, etc.) will not operate unless the equipment is correctly configured. Relate the terms to the specific objectives in the unit. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information)**

- Relate the terms to concepts that the students already understand. For example, if the students have completed *Power Product Equipment Technician: Theory and Principles of Engine Operation,* correlate chassis electrical components and functioning to the operation and physics of chassis electrical systems. **(Listening; reading; reasoning; system interrelationships)**

Objective 2 State the functions of the major components of chassis electrical systems.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 1, "Major Components of Chassis Electrical Systems," to aid the discussion. **(Reading/listening for content)**

- Provide actual examples of various chassis electrical systems and give an overview of how they are similar and different. Discuss the role of the frame and chassis as a ground connection and the completion of circuits. For example, point out variations in ignition switch designs, circuit protection, shutoff systems, systems with alternators and those with external chargers, different gauge and indicator packages, AC and DC powered lighting systems, etc. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 3 State the functions of the types of safety shutoff devices used in chassis electrical systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Discuss the need for both types of safety shutoff devices. Display examples of equipment that have been damaged due to by-passing of safety devices or the absence of safety devices. Invite a guest speaker who has been injured by power equipment or one who has experience with those suffering such injuries to discuss the importance of personal safety shutoffs and shields. Explain to the students that some safety devices provide protection to both the operator and the equipment and that the key point of this objective is that the students understand that both types of devices exist. Discuss the fact that many of the devices are required by federal and state legislation and that disabling of the devices may violate applicable laws. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 4 Match types of personal-safety shutoff devices to their correct functions.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use illustrations and actual equipment to provide examples of the types of personal-safety shutoff devices. Relate the operation of these systems to concepts that the students have mastered in their previous studies, such as opening circuits to interrupt electrical flow. Use actual equipment to demonstrate the operation of each type of switch. Provide an overview of applications and associated service procedures for each type. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 5 Match types of equipment-safety shutoff devices to their correct functions.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use illustrations and actual equipment to provide examples of the types of equipment-safety shutoffs. Relate the operation of these systems to concepts that the students have mastered in their previous studies, such as opening circuits to interrupt electrical flow. Use actual equipment to demonstrate the operation of each type of switch. Provide an overview of applications and associated service procedures for each type. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 6 Describe the types of lights used in chassis electrical systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Use illustrations as well as actual equipment to describe the operation of alternating-current and direct-current light systems. Use circuit diagrams to examine how the ignition switch, light switch, alternator, battery, fuses, lights, and other components are tied together. Show how some systems are wired for battery power and some are wired for alternator power. Have the students consider why it would be desirable to use the alternator to power the lights. Point out how the headlights are generally wired as parallel circuits. Have the students discuss why this would be the case and demonstrate the problem of a series circuit if required for student understanding. Use lighting systems as a means of covering wire gauges, color codes, and connectors. Many pieces of equipment now have connector blocks, while spade and ring crimp connectors are still common. Discuss varieties of light switches, such as toggle switches, rocker switches, pull knobs, etc. **(Listening; reasoning; science; seeing things in the mind's eye; system interrelationships)**

Objective 7 List typical service procedures required for chassis electrical systems.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Use the discussion of repairing versus replacing a gauge as a lead-in to this objective. Demonstrate service procedures. Have students practice manipulative skills, particularly if they are unfamiliar with the use of test equipment. Ensure that your students can correctly measure electrical characteristics and isolate circuit defects. **(Listening; reasoning; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**
- Provide your students with troubleshooting problems either as part of the job-sheet activities or as a separate exercise. Include cases of poor grounding. Have the students identify the service procedures that would be required in response to the problems detected. **(Listening; reasoning; acquiring, organizing, interpreting, and processing information; applying technology; system interrelationships; troubleshooting)**

Objective 8 Complete statements about the principles of operation of electric equipment drives.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Display various types of electric equipment drives. Demonstrate their operation and the electrical interface with the power product equipment. Provide the students with electrical diagrams and schematics for the equipment. Use a variety of electric motors. Point out circuit-protection devices, safety switches, and other features of the circuits. Provide the students with troubleshooting scenarios based on the circuits being discussed. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information)**

Objective 9 List typical service procedures required for electric equipment drives.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Demonstrate the procedures listed and relate them to the job sheets. Discuss service-manual procedures and the need to apply electrical principles when doing such procedures, such as knowing how to check for continuity or measure resistance when a service procedure does not specify how but may simply list a value. Emphasize personal and equipment safety concerns. Relate the procedures to those that the

students have already mastered. **(Listening; reasoning; applying technology; seeing things in the mind's eye; system interrelationships)**

Objective 10 Identify the major components of electromagnetic clutches.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 2, "Major Components of Electromagnetic Clutches," to aid the discussion. **(Reading/listening for content)**
- Expand your discussion of electrical concepts to discuss and demonstrate electromagnetism. This can be done easily with batteries and copper wire along with a soft iron core as described in many physics books. Have the students recall the purpose and operation of mechanical clutches. Then have students brainstorm how electromagnetism could be used in a device that serves as a clutch. Show and demonstrate the operation of electromagnetic clutches on a variety of equipment. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 11 Complete statements about the principles of operation of electromagnetic clutches.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Continue your discussion of electromagnetic clutches by examining the operation of one such system in detail. Go over each component and its purpose. Display an electrical schematic to show the source of electricity and the flow of electricity with the switch closed. Repeat the demonstration with other clutch systems and point out the corresponding components and actions that achieve the same functions. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Objective 12 List typical service procedures required for electromagnetic clutches.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**
- Demonstrate the procedures and relate them to the job sheets. Use service manuals and other reference materials. Guide the students through troubleshooting problems they are likely to encounter with electromagnetic clutches. Discuss the effects of a poor electrical system, such as shorts or low battery output, on electromagnetic clutches. Discuss tools to be used and concerns such as polarity. Use a variety of equipment so that the students will see numerous types of switches, circuit protection devices, etc. **(Listening; reasoning; seeing things in the mind's eye; system interrelationships)**

Suggested Activities

Objective 13 Label common symbols used on electrical schematics.

- Read and discuss with students the information presented in this section of the information sheet. Use Transparency 3, "Common Symbols Used on Electrical Schematics," to aid the discussion. **(Reading/listening for content)**

- Provide actual components. Adjust your presentation to the students needs as most of them should be fairly familiar with electrical symbols. Emphasize chassis electrical schematic diagrams and help the students interpret them. Relate the diagrams to actual equipment and point out the components, wire routing, and interfaces shown in the diagrams as they occur on the equipment. Demonstrate the effect of open switches, etc., on the equipment as interpreted on the diagrams. Point out electrical specifications in service manuals, such as resistance values, and measure those values, relating test points to the circuit diagrams. **(Listening; reasoning; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

Objective 14 State functions of specialty instruments used in electrical-system repair.

- Read and discuss with students the information presented in this section of the information sheet. **(Reading/listening for content)**

- Provide actual equipment to provide examples of the various types of instruments. Exhibit both gauges and indicators for various types of circuits, including charging systems, lubrication, fuel, temperature, etc. Use an ammeter or similar gauges to discuss their operation. Have students price gauges in catalogs and then evaluate the cost of replacing gauges with the cost of repairing internal defects. **(Listening; reasoning; seeing things in the mind's eye; interpreting and processing information; system interrelationships)**

Assignment Sheet 1 Interpret chassis-electrical-system schematics.

- Have students locate Assignment Sheet 1. Read the introduction and directions to the assignment. **(Reading/listening for direction)**

- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Reading; writing; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

- Answer any student questions and have students complete Assignment Sheet 1.

Assignment Sheet 2 Determine chassis-electrical-system service specifications and parts requirements.

- Have students locate Assignment Sheet 2. Read the introduction and directions to the assignment. **(Reading/listening for direction)**

Suggested Activities

- Make resources available that will allow the students to determine the required information. Tailor the assignment sheet to equipment used in your facility. **(Reading; writing; seeing things in the mind's eye; acquiring, organizing, interpreting, and processing information; system interrelationships)**

- Answer any student questions and have students complete Assignment Sheet 2.

Job Sheet 1 Perform routine maintenance on chassis electrical systems.

- Have students locate Job Sheet 1 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on chassis electrical systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the chassis electrical system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 1.

Job Sheet 2 Repair chassis electrical systems.

- Have students locate Job Sheet 2 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing chassis electrical systems. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the chassis electrical system and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 2.

Job Sheet 3 Perform routine maintenance on electrical equipment drives.

- Have students locate Job Sheet 3 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on electrical equipment drives. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires routine maintenance of the electrical equipment drive and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 3.

Suggested Activities

Job Sheet 4 Repair electrical equipment drives.

Have students locate Job Sheet 4 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing electrical equipment drives. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.

- Provide students with power product equipment that requires repair of the electrical equipment drive and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 4.

Job Sheet 5 Perform routine maintenance on electromagnetic clutches.

- Have students locate Job Sheet 5 and the worksheet associated with the job sheet. Demonstrate the procedures for performing routine maintenance on electromagnetic clutches. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment that requires routine maintenance of the electromagnetic clutch and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 5.

Job Sheet 6 Repair electromagnetic clutches.

- Have students locate Job Sheet 6 and the worksheet associated with the job sheet. Demonstrate the procedures for repairing electromagnetic clutches. Review with students the worksheet associated with the job sheet, and have them obtain copies of the worksheet for each attempt that will be required.
- Provide students with power product equipment that requires repair of the electromagnetic clutch and have them complete the pre-performance check (Part A) on the worksheet. Evaluate the pre-performance check, and when a student has completed it satisfactorily, have him/her complete Job Sheet 6.

Evaluation

- Evaluate the assignment sheets. See the evaluation criteria listed at the top of each assignment sheet as well as the teacher page "Answers to Assignment Sheets."
- Evaluate the job sheets.

When the student is ready to perform a specific task, obtain a copy of the worksheet associated with each job sheet. Worksheets may be found in the student edition and in the teacher pages following the transparency masters. Then, observe the student performing the procedure.

Suggested Activities

After the student has completed the procedure, rate the student using the criteria provided on the worksheet. If the student's performance is unacceptable, have the student review the materials and perform the procedure again for evaluation.

Two sample performance evaluation keys are provided below. Many other keys are available. Select one evaluation key (grading scale) that best fits your program needs.

Performance Evaluation Keys

Sample A

4 — Skilled—Can perform job with no additional training.
3 — Moderately skilled—Has performed job during training program; limited additional training may be required.
2 — Limited skill—Has performed job during training program; additional training is required to develop skill.
1 — Unskilled—Is familiar with process, but is unable to perform job.

Sample B

Yes—Can perform job with no additional training.

No—Is unable to perform job satisfactorily.

- Give the written test. See the teacher page "Written Test."
- Evaluate the written test. See the teacher page "Answers to Written Test."
- Compile written-test, assignment-sheet, and job-sheet scores. See the teacher page "Unit Evaluation Form."
- Reteach and retest as required.

Suggested resources

Resources used in developing this unit

Print media

- Graf, Rudolf F., and George J. Whalen. *VNR Illustrated Guide to Power Tools.* New York: Van Nostrand Reinhold Company, 1978.
- Hawker, M. F. J., and J. F. Keenlyside. *Horticultural Machinery,* 3rd ed. Essex, England: Longman Group Limited, 1985.
- Jorgensen, Eric, editor. *Kawasaki 250-750cc Triples,* 5th ed. Arleta, California: Clymer Publications, 1979.
- *MTD Yard-Man Technical Service Handbook.* Cleveland, Ohio: MTD Products, Inc., 1996.

Suggested Activities

- *Outdoor Power Equipment Repair.* Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, 1985.
- *Power Tools and Equipment.* Alexandria, Virginia: Time-Life Books, Inc., 1989.
- *Power Trains: Compact Equipment.* Moline, Illinois: Deere and Company, 1991.
- *Riding Lawn Mower Service Manual,* 3rd ed. Overland Park, Kansas: Intertec Publishing Corporation, 1989.
- *Small Tractor Service Manual.* Overland Park, Kansas: Intertec Publishing Corporation, 1984.
- Wright, Ron. *Harley-Davidson Sportsters,* 7th ed. Arleta, California: Clymer Publications, 1986.
- *Yard and Garden Tractor Service Manual,* 1st ed. Overland Park, Kansas: Intertec Publishing Corporation, 1992.

Suggested supplemental resources

Print media

- *Outdoor Power Equipment* magazine. Adams/Green Industry Publishing, 68860 Perez Road, Suite J, Cathedral City, California 92234. Web site: http://www.outdoorpowerequipment.com
- *Power Equipment Trade* magazine. Hatton-Brown Publishers, Inc., P. O. Box 2268, Montgomery, Alabama 36102.
- *Technical Handbook.* Describes the makes and types of equipment produced by MTD—one of the nation's largest manufacturers. The book covers service for most equipment systems and various types of equipment. Both light- and heavy-duty equipment types are included. Available from MTD Products, Inc. Call 1-800-422-3381.
- Service manuals for systems covered in this unit.
- Parts catalogs for systems covered in this unit. Available from equipment manufacturers.

Non-print media

- *Basic Electronic Test Instruments.* Bergwall Productions, Inc., 540 Baltimore Pike, Chadds Ford, Pennsylvania 19317, (800) 645-3565.
- *Special Five Tapes in One.* Section 3 of this program provides information on the operation of the battery and charging system and troubleshooting of these systems. The second section addresses electrical troubleshooting of riding lawn mowers and garden tractors. This unit can also be used with *Lawn and Garden Equipment,* Unit 3, "Heavy-Duty Lawn and Garden Equipment." Available from MTD Products, Inc. Call 1-800-422-3381.

Chassis Electrical Systems
Unit 7

Answers to Assignment Sheets

Assignment Sheet 1—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1.
   a. Charger terminal
   b. Engine, mower-clutch, clutch-brake
   c. Black
   d. True
   e. The starter is grounded to the equipment frame.

2.
   a. No
   b. No
   c. Red
   d. True
   e. Parallel. The positive terminals and the negative terminals are interconnected.

3.
   a. Blue
   b. 20 amp
   c. 18 gauge
   d. True
   e. Yes

4.
   a. Blue
   b. Alternator
   c. "a" terminal
   d. True
   e. 12 gauge, yellow

Assignment Sheet 2—Student performance should be evaluated according to the criteria listed on the assignment sheet. Content of each item in the exercise may be evaluated using the following suggestions as guides.

1. Answers for "a" through "e" depend on the references used.

2.
   a. 10 amp
   b. 20 amp
   c. 15 amp
   d. 25 amp
   e. 20 amp

Answers to Assignment Sheets

3.

Equipment	Seat switch	Clutch/brake switch	Neutral switch	Blade/mower switch
Ariens electric-start riding lawn mowers	X		X	X
John Deere Model 57 riding lawn mowers		X		X
Ford electric-start riding lawn mowers		X		X
Roper Model 863 riding lawn mowers		X		X
Wheel Horse electric-start riding lawn mowers	X		X	X

4.
- a. An open circuit or bad ground
- b. 8 volts
- c. 2.75 to 3.6 ohms
- d. ⅝ inch NC
- e. Answer depends on the references used.

5.
- a. 1
- b. One Belleville washer, one thrust washer, bushing, one thrust washer, one Belleville washer
- c. 25 to 30 in-lbs (2.8-3.4 N•m)
- d. Replace the motor
- e. Upon starting to lift

Chassis Electrical Systems
Unit 7

Answers to Written Test

1.
   a. 4
   b. 7
   c. 1
   d. 6
   e. 2
   f. 5
   g. 3

2.
   a. Prevents the engine from starting if the equipment drives are engaged
   b. Prevents the engine from starting if the transmission is not in *park* or *neutral*
   c. Allows the operator to direct or shut off electricity to the starter or ignition system
   d. Provide the operator with information about the functioning of some equipment systems
   e. Provide illumination in front of the equipment
   f. Generates electricity to recharge the battery and to operate other systems
   g. Prevents the engine from starting or running if there is no weight on the seat
   h. Provides the electrical path to form complete circuits
   i. Provides electricity for some chassis electrical components

3.
   a. Stop the operation or movement of the equipment to protect the operator or other people in the immediate area

   b. Stop or limit the operation of the equipment to prevent damage to the equipment

4.
   a. 3
   b. 7
   c. 4
   d. 2
   e. 1
   f. 5
   g. 6
   h. 8
   i. 9

5.
   a. 6
   b. 3
   c. 2
   d. 5
   e. 4
   f. 1

6.
   a. Lights that receive their power from the alternator and will not operate unless the engine is running

   b. Lights that receive their power from the battery and will operate whether or not the engine is running

7. Answer should include any four of the following.

- Measure electrical characteristics such as voltage, voltage-drop, and resistance
- Remove and replace electrical components
- Adjust alternator-belt tension
- Charge battery
- Replace bulbs
- Repair wiring and electrical coils

Answers to Written Test

8. a. switch
   b. battery
   c. transmission

9. Answer should include any three of the following.

   - Measure circuit electrical characteristics such as voltage and resistance
   - Remove and replace electrical components
   - Adjust alternator-belt tension
   - Repair wiring and electrical coils

10. a. Return mechanism
    b. Clutch output
    c. Clutch interface
    d. Actuator wire
    e. Field coil
    f. Engine-input linkage

11. a. rotor assembly
    b. armature
    c. field coil; rotor assembly
    d. rotor assembly
    e. field coil; collapse
    f. Centrifugal force; spring tension
    g. armature; rotor assembly

12. Answer should include any three of the following.

    - Measure circuit electrical characteristics such as voltage and resistance
    - Remove and replace electrical components
    - Adjust alternator-belt or engine-belt tension
    - Repair wiring and electrical coils

13. a. Lamp
    b. Battery
    c. Component
    d. Switch
    e. Fuse
    f. Conductor
    g. Diode
    h. Coil
    i. Resistor
    j. Ground

14. a. Indicates whether current is present
    b. Measures voltage, current, or resistance
    c. Measures voltage
    d. Measures current
    e. Measures resistance

Chassis Electrical Systems
Unit 7

Written Test

Name ______________________________ Score ______________

1. Match terms associated with electrical systems to their correct definitions. Write the numbers on the blanks provided.

_______ a. Force that causes electrical flow

_______ b. Unit of measure for the amount of electromotive force in an electrical current

_______ c. Unit of measure for the rate of electrical flow

_______ d. Opposition of a substance to electrical flow

_______ e. Ability of a system to support electrical flow as a complete circuit

_______ f. Unit of measure for resistance to electrical flow

_______ g. Rate of electrical flow

1. Ampere
2. Continuity
3. Current
4. Electromotive force
5. Ohm
6. Resistance
7. Volt

2. State the functions of the major components of chassis electrical systems. Write your answers on the blanks provided beside each of the components listed below.

a. Equipment interlock switch ______________________________

____

b. Neutral safety switch ______________________________

____

c. Ignition switch ______________________________

____

d. Gauges/indicator lights ______________________________

____

e. Headlights ______________________________

____

f. Alternator ______________________________

____

g. Seat interlock switch ______________________________

____

h. Ground ____

____

i. Battery ____

____

3. State the functions of the types of safety shutoff devices used in chassis electrical systems. Write your answers on the blanks provided beside each type of device listed below.

a. Personal-safety shutoff devices ______________________________

____

b. Equipment-safety shutoff devices ______________________________

____

4. Match types of personal-safety shutoff devices to their correct functions. Write the numbers on the blanks provided.

_______ a. Prevents the engine from starting when the equipment drive or drive-train clutch is engaged

_______ b. Shuts down the engine or equipment drives when there is no pressure on the seat

_______ c. Stops the engine and blade rotation upon release of a control handle

_______ d. Stops the rotation of the blade without stopping the engine upon release of a control handle

_______ e. Shuts down the equipment if the blades or other specific devices are in operation when the transmission/transaxle is shifted into reverse

_______ f. Prevents the engine from starting if the equipment is not configured in a certain way, such as having the transmission in *neutral* or *park*

_______ g. Prevents the engine from starting when the PTO is engaged

_______ h. Prevents the engine from starting or operating if protective shields are not in place

_______ i. Prevents the engine from running when the equipment exceeds a specified angle with respect to horizontal

1. Back-up switch
2. Blade brake
3. Clutch switch
4. Flywheel brake
5. Neutral safety switch
6. PTO-off switch
7. Seat interlock switch
8. Shield switch
9. Tilt switch

Written Test

5. Match types of equipment-safety shutoff devices to their correct functions. Write the numbers on the blanks provided.

_______ a. Shuts down the equipment when the equipment exceeds a specified angle with respect to horizontal

_______ b. Shuts down the equipment when the lubrication-system pressure drops below a specific reading

_______ c. Shuts down the equipment when the oil level in the lubrication-system reservoir drops below a specific level

_______ d. Shuts down the equipment when a monitored temperature, such as coolant or oil temperature, exceeds a specific limit

_______ e. Prevents the engine speed from exceeding a specific rate

_______ f. Prevents the flow of fuel when the engine is not running

1. Fuel shutoff
2. Oil-level switch
3. Oil-pressure switch
4. RPM limiter
5. Temperature switch
6. Tilt switch

6. Describe the types of lights used in chassis electrical systems. Write your answers on the blanks provided beside each type of light listed below.

a. Alternating-current lights ____

____

b. Direct-current lights ____

____

7. List four of the typical service procedures required for chassis electrical systems. Write your answers on the blanks provided.

a. ____

b. ____

c. ____

d. ____

8. Complete statements about the principles of operation of electric equipment drives. Write the missing word(s) on the blanks provided in the statements below.

a. An electrical ______________ is provided to allow the operator to turn the equipment on or off.

b. Electricity from the alternator or ______________ is routed to an electric motor.

c. The electric motor powers the equipment directly or powers a ______________ that transfers the force to the equipment.

Written Test

9. List three of the typical service procedures required for electric equipment drives. Write your answers on the blanks provided.

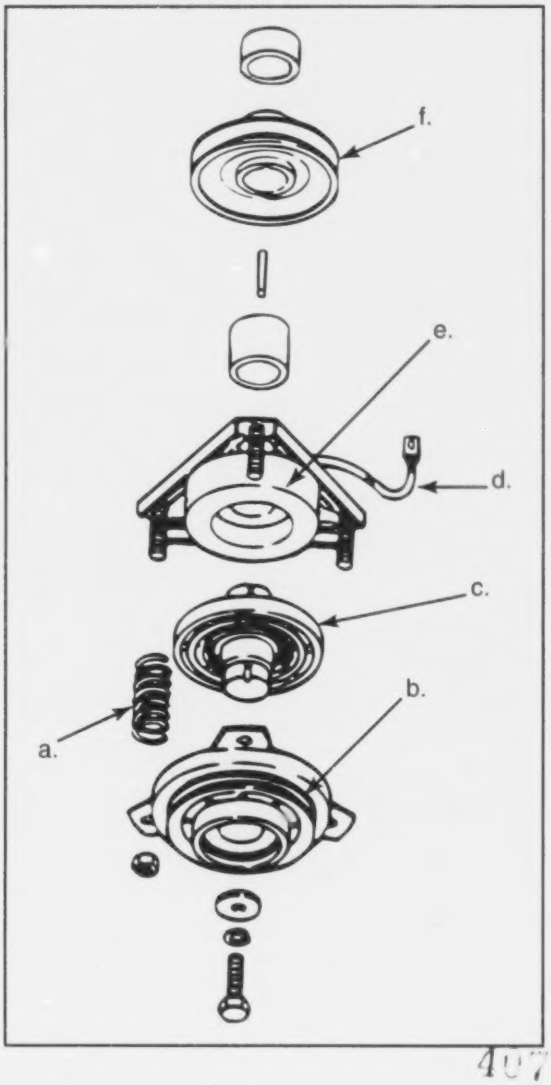
   a. ____

   b. ____

   c. ____

10. Identify the major components of electromagnetic clutches. Select your answers from the list below and then write your answers on the blanks provided beside the illustration.

Engine-input linkage
Field coil
Actuator wire
Clutch interface
Clutch output
Return mechanism



a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

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Written Test

11. Complete statements about the principles of operation of electromagnetic clutches. Write the missing word(s) on the blanks provided in the statements below.

    a. The ____________________ is mounted to the end of the engine crankshaft.

    b. The ____________________ is mounted to the end of the transmission or equipment-drive shaft.

    c. With the engine running and the clutch engaged, an electromagnetic field is generated in the ____________________ and ____________________.

    d. The magnetic field holds the armature and clutch output to the ____________________, allowing power to be transferred from the engine.

    e. When the clutch pedal is depressed, the flow of electricity to the ____________________ is disrupted, causing the electromagnetic field to ____________________.

    f. ____________________ or ____________________ separates the rotor assembly and the armature.

    g. When the clutch pedal is released, the electromagnetic field is restored, causing the ____________________ to be held to the ____________________.

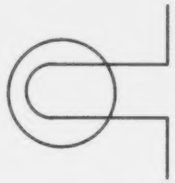
12. List three of the typical service procedures required for electromagnetic clutches. Write your answers on the blanks provided.

    a. ____

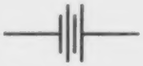
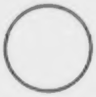
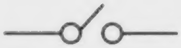
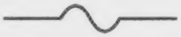
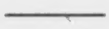
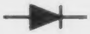
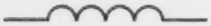
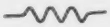
    b. ____

    c. ____

13. Label common symbols used on electrical schematics. Write your answers on the blanks provided under each of the illustrations below and on the next page.



a. ____________________

 b. ____________	 c. ____________	 d. ____________
 e. ____________	 f. ____________	 g. ____________
 h. ____________	 i. ____________	 j. ____________

14. State functions of the specialty instruments used in electrical-system repair. Write your answers on the blanks provided beside each of the instruments listed below.

   a. Continuity light ____

   b. Multimeter ____

   c. Voltmeter ____

   d. Ammeter ____

   e. Ohmmeter ____

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Permission to duplicate this test is granted

Chassis Electrical Systems
Unit 7

Unit Evaluation Form

Student name ______________________________ Unit rating ______________

Assignment-sheet ratings

Assignment Sheet 1—Interpret Chassis-Electrical-System Schematics Rating ________

Comments: ____

____

Assignment Sheet 2—Determine Chassis-Electrical-System Service Specifications and Parts Requirements Rating ________

Comments: ____

____

Job-sheet ratings

Job Sheet 1—Perform Routine Maintenance on Chassis Electrical Systems Rating ________

Comments: ____

____

Job Sheet 2—Repair Chassis Electrical Systems Rating ________

Comments: ____

____

Job Sheet 3—Perform Routine Maintenance on Electrical Equipment Drives Rating ________

Comments: ____

____

Job Sheet 4—Repair Electrical Equipment Drives Rating ________

Comments: ____

____

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Unit Evaluation Form

Job Sheet 5—Perform Routine Maintenance on Electromagnetic Clutches Rating ________

Comments: ______________________________

____

Job Sheet 6—Repair Electromagnetic Clutches Rating ________

Comments: ______________________________

____

Written-test scores

Pretest ________ Posttest ________ Other ________

Comments: ______________________________

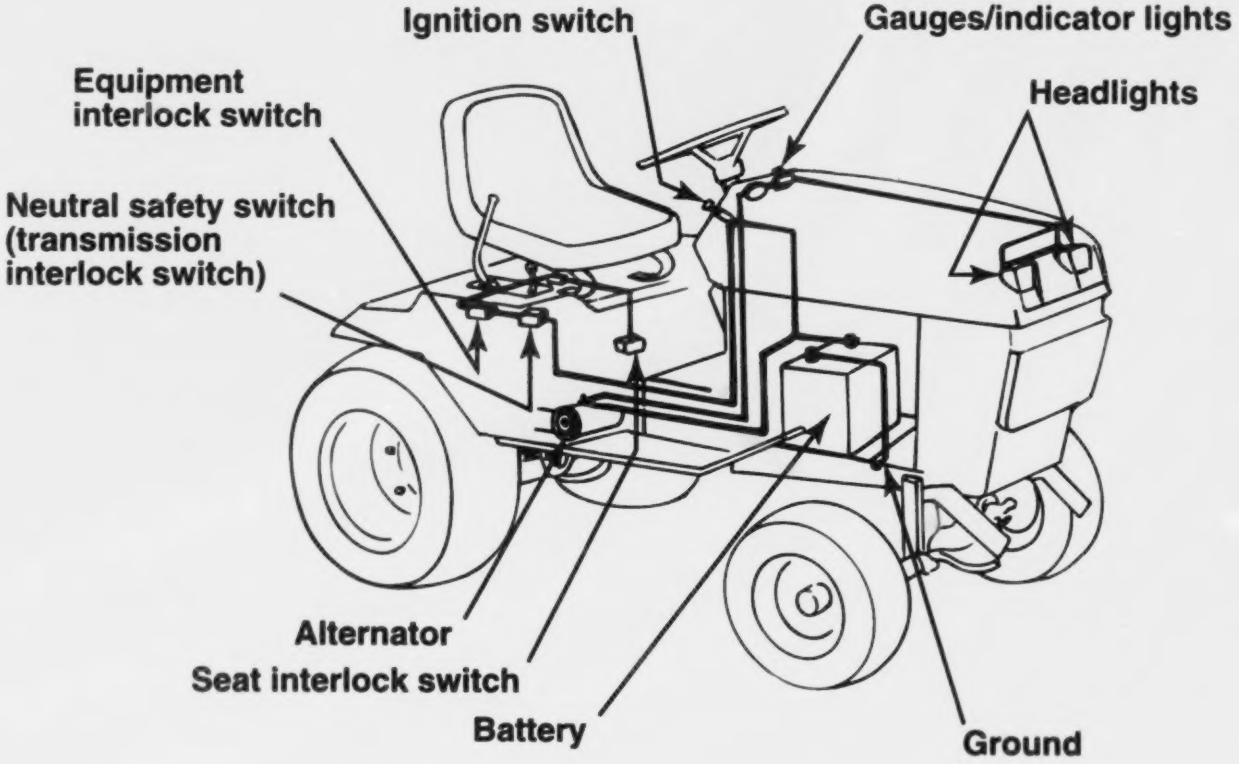
____

Teacher signature ______________________ Date ____________

Student signature ______________________ Date ____________

Permission to duplicate this form is granted.

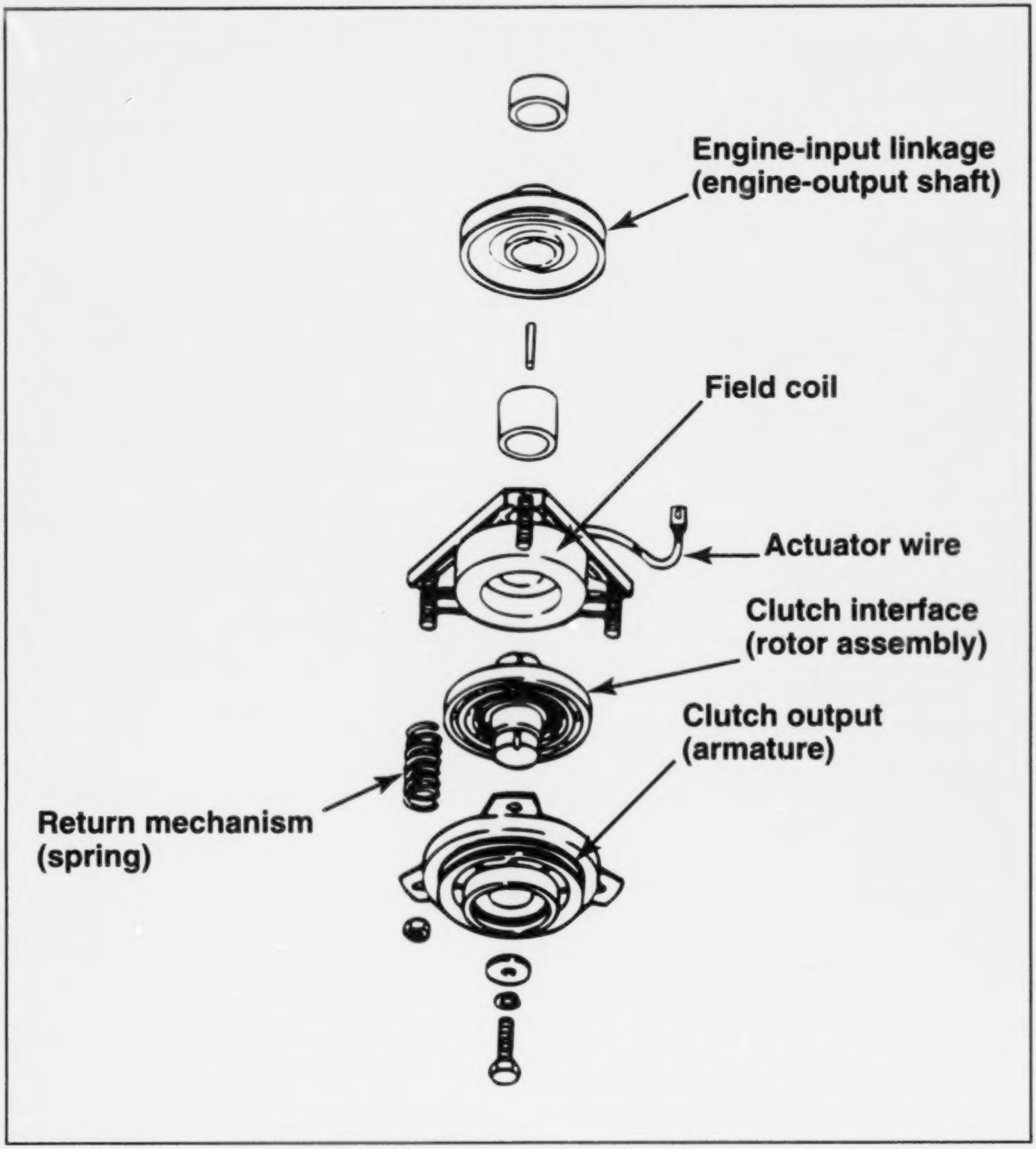
Major Components of Chassis Electrical Systems


Ignition switch
Gauges/indicator lights
Equipment interlock switch
Headlights
Neutral safety switch (transmission interlock switch)
Alternator
Seat interlock switch
Battery
Ground

Equipment Systems, Unit 7
Teacher Page 377

TM 1

Major Components of Electromagnetic Clutches


Engine-input linkage
(engine-output shaft)
Field coil
Actuator wire
Clutch interface
(rotor assembly)
Clutch output
(armature)
Return mechanism
(spring)

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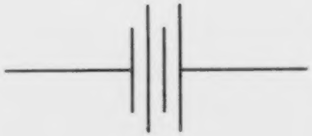
TM 2

Common Symbols Used on Electrical Schematics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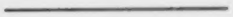
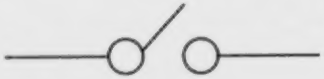
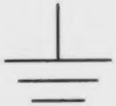
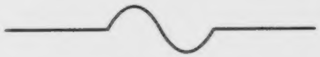
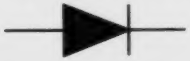
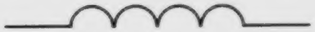

Conductor

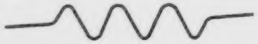

Switch

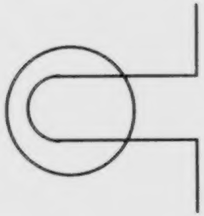

Ground

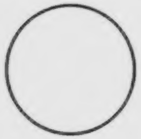

Fuse


Diode


Coil


Resistor


Lamp


Component

Job Sheet 1

Worksheet—Perform Routine Maintenance on Chassis Electrical Systems

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ____

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Worksheet—Perform Routine Maintenance on Chassis Electrical Systems

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

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Job Sheet 2

Worksheet—Repair Chassis Electrical Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: **Pre-performance check**

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 2

Worksheet—Repair Chassis Electrical Systems

Part B: Performance evaluation

Evaluation criteria **Rating**

Correct procedures identified for assigned equipment. ______

Procedures completed correctly. ______

Proper tools used correctly. ______

Safety precautions observed. ______

Service meets specifications. ______

Clean-up and follow-up actions adequate. ______

Overall rating ______

Evaluator's comments ____

____

____

Job Sheet 3

Worksheet—Perform Routine Maintenance on Electrical Equipment Drives

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 3

Worksheet—Perform Routine Maintenance on Electrical Equipment Drives

---

Part B: Performance evaluation

Evaluation criteria **Rating**

Correct procedures identified for assigned equipment. ______

Procedures completed correctly. ______

Proper tools used correctly. ______

Safety precautions observed. ______

Service meets specifications. ______

Clean-up and follow-up actions adequate. ______

Overall rating ______

Evaluator's comments ____

____

____

Job Sheet 4

Worksheet—Repair Electrical Equipment Drives

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ____

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ____

Job Sheet 4

Worksheet—Repair Electrical Equipment Drives

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	_______
Procedures completed correctly.	_______
Proper tools used correctly.	_______
Safety precautions observed.	_______
Service meets specifications.	_______
Clean-up and follow-up actions adequate.	_______
Overall rating	_______

Evaluator's comments ____

____

____

Job Sheet 5

Worksheet—Perform Routine Maintenance on Electromagnetic Clutches

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Worksheet—Perform Routine Maintenance on Electromagnetic Clutches

---

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Job Sheet 6

Worksheet—Repair Electromagnetic Clutches

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 6

Worksheet—Repair Electromagnetic Clutches

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	________
Procedures completed correctly.	________
Proper tools used correctly.	________
Safety precautions observed.	________
Service meets specifications.	________
Clean-up and follow-up actions adequate.	________
Overall rating	________

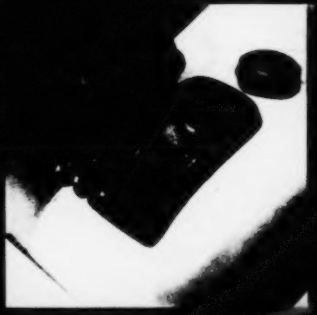
Evaluator's comments ____

____

____

Power Product Equipment Technician:

Equipment Systems



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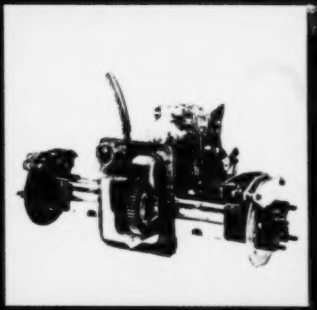

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Student Edition

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Power Product Equipment Technician:

Equipment Systems

Student Edition

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Equipment Systems

Student Edition

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Principles of Power Transmission
Unit 1

Objective Sheet

Unit objective

After completing this unit, the student should be able to describe the principles of power transmission as they apply to power product equipment drive systems. The student should demonstrate these competencies by completing the assignment sheet and by scoring a minimum of 85 percent on the written test.

Specific objectives

After completing this unit, the student should be able to

1. Complete statements concerning the basic concepts of physics related to power transmission.
2. Define the types of power-transmission systems.
3. Define the term *drive system*.
4. State the functions of the types of drive systems used in power product equipment.
5. State the function of a clutch in a drive system.
6. List the types of drive trains used in power product equipment.
7. List the characteristics used to classify drive trains.
8. Distinguish between the definitions of the types of output configurations used in drive trains.
9. List the types of equipment drives used in power product equipment.
10. State the functions of the major components of an equipment drive.
11. Match types of clutch systems to their correct descriptions.
12. State the functions of the major components of a clutch system.
13. List devices used to actuate clutches.
14. Determine power-transmission characteristics of power product equipment. (Assignment Sheet 1)

Principles of Power Transmission
Unit 1

Information Sheet

1. **Statements concerning the basic concepts of physics related to power transmission**

Note: As indicated by the word *power* in the term *power product equipment*, a key concept in the study of power product equipment is power transmission. There are numerous definitions of the word *power*, but its application with regard to the equipment discussed in this publication has a scientific basis. Power transmission and related concepts are part of the field of science known as *physics*, and therefore, a technician must understand some basic concepts of physics in order to understand how power product equipment works and how to service it.

- **The universe consists of two components: (1) those things that take up space—known as *matter*—and (2) movement or the ability to produce movement—known as *energy*.**

Note: To make a distinction between matter and energy is not strictly true with regard to science, but making this distinction is useful in your study of power product equipment. Actually, most physicists think that matter and energy are two forms of the same thing and that matter and energy can be converted from one form to the other. For example, the release of energy when fuel is ignited in an engine is a conversion of matter (gasoline) into energy (heat, light, and sound, primarily). Therefore, many scientists say that the universe is composed of *mass-energy*—mass being that property of matter that allows it to take up space and to have weight (be attracted by gravity).

- **Matter commonly occurs in one of three states on earth: (1) a solid, (2) a liquid, or (3) a gas.**

Note: *Solids* are those objects that have definite shape and take up a specific amount of space (volume), such as the piece of paper upon which this text is printed. *Liquids*, like water and gasoline, occupy a definite amount of space but change shape easily to fit their container. *Gases* change shape and volume to fill their containers. Scientists theorize that other states of matter exist but these states are not applicable to power product equipment.

- **Energy occurs in many forms, such as heat, light, electrical energy, chemical energy, mechanical energy, and nuclear energy.**

Note: All matter contains energy. Because matter consists of atoms and atoms consist of electrons that orbit the atom's nucleus, there is movement (energy) at the atomic level in all matter. However, energy can also exist in "pure" forms outside of matter. For example, it is energy in the metal that makes an engine block feel hot after the engine has been operating, and it is also energy radiating from the hot metal in the engine that makes the air surrounding the engine feel hot.

- **Energy can be applied to matter to change its shape or cause it to move.**

Note: If you place an ice cube on the engine block discussed in the previous note, the ice will melt (change to a liquid) and eventually evaporate (change to a gas). This is because the ice and then the water absorb heat energy from the engine. Engines are designed in such a way that the energy produced by igniting the fuel/air mixture moves the piston, crankshaft, and other parts in specific patterns.

Information Sheet

- **The action of energy upon matter is called *work*—the movement or changing of shape of matter, including changing its state of matter.**

  Note: One classic definition of the word *energy* is "the ability to do work." The reason that this definition has been popular is that it is difficult to say what energy is because it takes on so many and such varied forms, but it is easy to say what it is good for. In this case, doing work means that matter is moved or its shape is changed. In fact, some newer texts define *energy* as "the ability to produce movement or change." You can see that this principle applies whichever way energy is defined.

- **The amount of work that a quantity of energy can do is called *force*.**

  Note: At first, you might want to ask, What is the difference between force and energy if they both have to do with accomplishing work? Assume, for example, that it takes 100 pounds of pressure on each square inch of piston face to cause the piston to move and turn the crankshaft. However, if the fuel/air mixture is improperly set so that when the mixture is ignited only 75 pounds of pressure are exerted on each square inch of the piston face, energy is still released as heat, light, and sound, but that amount of energy does not produce enough force to move the piston.

- **The amount of force that is applied within a given period of time is called *power*.**

  Note: If it takes 100 pounds of force to move an object 10 feet, it does not matter whether the force is applied in 1 second or 1 minute—the same amount of force is required. But, your experience tells you that there is a difference between going 10 feet per minute and going 10 feet per second, just as a car uses more gasoline going 60 miles per hour versus traveling 40 miles per hour, or as you tire faster running than walking. This difference is addressed in the concept of power. You are already familiar with the term *horsepower*, which is simply one unit of measure for power.

- **Force, and therefore power, can be moved from its source to produce work at a location distant from the source through a process called *transmission*.**

  Note: Power product equipment offers numerous examples of transmitting power. For example, with a typical riding lawn mower, power is transmitted from the engine to drive the wheels and turn the mower blade. The engine may be used to turn the shaft of the alternator, which in turn generates electricity to recharge the battery and power the lights. Power from the battery is transmitted through a cable to the starter. Even the act of steering the riding lawn mower is an example of transmitting power from the operator through the steering column to the wheels.

2. **Types of power-transmission systems and their definitions**

- **Mechanical**—System that uses belts, pulleys, chains, shafts, and similar linkages to transmit power
- **Hydraulic**—System that uses liquid to transmit power
- **Pneumatic**—System that uses air or other gases to transmit power
- **Electrical**—System that uses electricity to transmit power
- **Magnetic**—System that uses the properties of magnetism to transmit power

Information Sheet

3. Definition of the term *drive system*

Note: The previous books in the *Power Product Equipment Technician* series have provided you with an overview of the internal-combustion engine and the systems—starting, charging, electrical, etc.—used on power product equipment to support those engines. In this book, you will study what is done with the power produced by the power product equipment engines.

- **Drive system**—Generic term applied to any collection of components that transmit power from an engine to a point where work is done

4. Types of drive systems used in power product equipment and their functions

Note: The power developed by an engine is used in two primary ways in power product equipment. Some equipment is capable of moving under its own power. Movement is accomplished by means of the drive wheels, which may be connected to the engine in various ways, such as through the drive axle, differential, drive chain, transmission, and engine-output shaft and belt. These components or the corresponding components in a different type of system are collectively referred to as the *drive train* or *drive line*. Only self-propelled types of power product equipment have a drive train. But, all power product equipment uses one or more paths to operate attachments, and the components that make up these paths are called *equipment drives*.

- **Drive train**—Provides the force that allows the equipment to move under its own power

  Note: As noted above, not all types of power product equipment have a drive train. However, riding lawn mowers, all-terrain vehicles, self-propelled mowers, motorcycles, snowmobiles, and garden tractors are just some of the types of self-propelled equipment that have drive trains. The drive train may be as simple as using the rotary force of the engine to turn one axle on a walk-behind mower, or it may contain a transmission that allows the operator to vary the gears (speeds) and direction (forward and reverse) of equipment travel.

- **Equipment drive**—Provides the force that powers those attachments that accomplish the work performed by the equipment

  Note: The purpose of power product equipment is to accomplish work, which generally requires attaching some type of mechanism to the engine so that the output of the engine can be made to do that work. In the case of a chain saw, for example, the equipment-drive path is fairly simple—generally, a sprocket on the end of the engine crankshaft that drives a chain that contains cutters. In other cases, the equipment drive may route power along several belts and pulleys or gears. Even types of power product equipment that appear to be primarily used for transportation, such as a golf cart, may have equipment drives in the form of belt systems to turn the alternator or to power a hydraulic pump in the steering system.

5. Function of a clutch in a drive system—Controls (allows or stops) the transmission of power from the engine to a drive system (drive train or equipment drive)

Note: Many pieces of power product equipment have more than one clutch. The equipment may have a clutch or combination clutch/brake to engage or disengage the engine and transmission, while other clutches (often gears or pulleys) are used to engage or disengage equipment drives. Clutches may be automatic or operator controlled.

Information Sheet

6. Types of drive trains used in power product equipment

- **Mechanical**

  Note: Mechanical drive trains use belts, discs, gears, chains, shafts, and similar devices to regulate and transfer power from the engine. Mechanical drive trains are the most common type used on small equipment such as self-propelled, walk-behind lawn mowers. Many older riding lawn mowers, garden tractors, motorcycles, and snowmobiles have mechanical drive trains, though most new models use hydrostatic drive trains. In Unit 2, "Mechanical Drive Systems," you will learn more about this type of drive train.

- **Hydraulic**

  Note: True hydraulic drive trains are rarely used on power product equipment. But, when they are used, they operate much like the systems commonly referred to as *automatic transmissions* in automobiles—they automatically provide changes in transmission-speed settings based on vehicle speed and load without the operator's making any adjustments. You will study more about this type of drive train in Unit 4, "Hydraulic and Pneumatic Drive Systems."

- **Hydrostatic**

  Note: Hydrostatic drive trains use at least one hydraulic pump and a motor to regulate and transfer power from the engine. The operator sets the speed and, often, the direction by changing positions of one or more actuators, and in most equipment using this type of drive train, the operator must bring the equipment to a stop in order to change speed and direction (although some newer systems provide what is called *shift-on-the-go control*). You will also study more about this type of drive train in Unit 4.

7. Characteristics used to classify drive trains

Note: The four drive-train characteristics listed below affect how a drive train can be used and the related service requirements for the drive train.

- **Method of power transmission**

  Examples: Mechanical, hydraulic, hydrostatic (see Objective 6)

- **Drive-direction capabilities**

  Examples: Forward only, forward and reverse

- **Output configuration**

  Examples: Transmission, transaxle (see Objective 8)

- **Number of speeds**

  Examples: Single-speed, multiple-speed, or variable-speed transmission or transaxle

Information Sheet

Note: The term *speed* refers to the function of a transmission or transaxle to provide a specific rate of drive-wheel rotation for a given engine speed. This rate is determined by the size of the gears, pulleys, sprockets, and other drive devices used as well as by the way in which these devices are combined in the transmission/transaxle. Thus, a transmission may provide a single speed or, through the use of multiple drive devices, more than one speed. Multiple-speed transmissions/transaxles in power product equipment are commonly two-, three-, and five-speed designs for mechanical drive trains and virtually any range up to approximately 20 speeds for hydrostatic drive trains.

8. Types of output configurations used in drive trains and their definitions

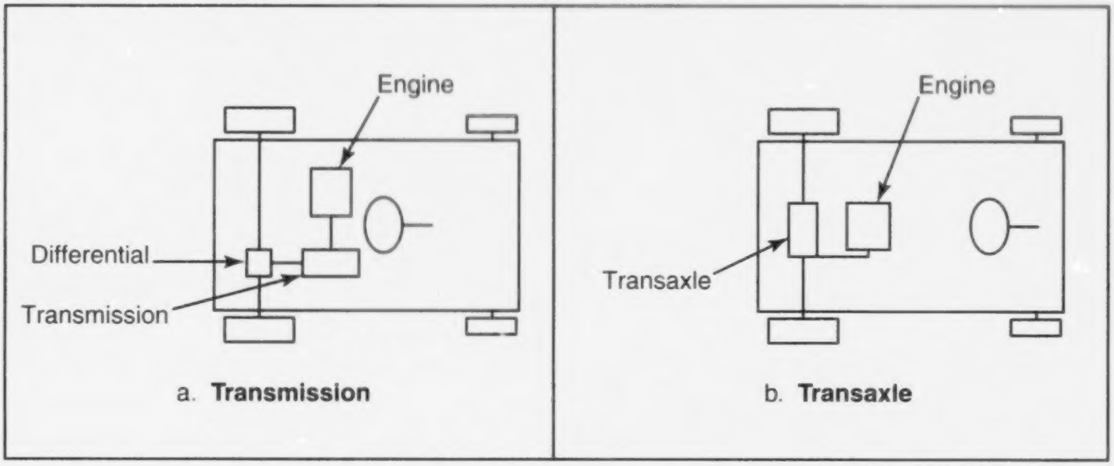
- **Transmission**—Output configuration that transfers engine power to the final drive at one or more speeds and often in forward and reverse directions (see Figure 1-a)

  Note: The final drive is the part of the drive train that makes contact with the ground to propel the equipment. In most power product equipment, the final drive consists of a solid axle with a hub to which the tire-and-wheel assembly is mounted. The wheels involved may be front or rear wheels, or both. The drive axle is generally separated into two parts that meet in a gearbox called a *differential*. The differential allows the drive wheels to turn at different speeds during a turn. Transmissions provide output that is perpendicular to the drive axle, so the output must be redirected through pulleys or gears. A transmission may be as simple as a single pulley and belt between the engine and drive axle or as complicated as an integrated unit offering several speeds, forward and reverse direction, safety interlocks, and a parking gear to hold the equipment wheels locked.

- **Transaxle**—Output configuration that transfers engine power directly to the drive wheels (see Figure 1-b)

  Note: Transaxles are single units that serve the purpose of both a transmission and a differential. The sections of the drive axle extend from the transaxle with the drive wheels mounted to the end of them, in essence combining the transmission and differential in one unit.

Figure 1: Types of output configurations used in drive trains



a. **Transmission**

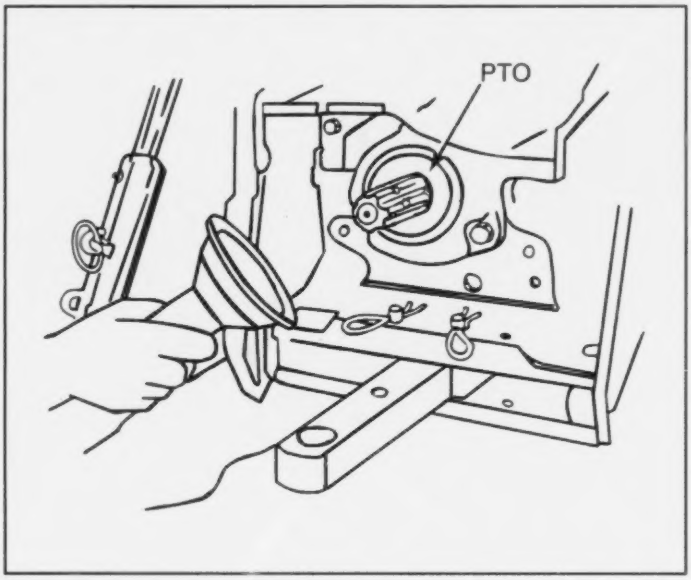
b. **Transaxle**

9. Types of equipment drives used in power product equipment

- **Mechanical power take-off** (mechanical PTO)

  Note: A power take-off (PTO) is a device that allows power from the engine to be redirected for use elsewhere (see Figure 2). In its simplest form, a mechanical-PTO equipment drive is a gear, pulley, or sprocket mounted to the end of the crankshaft and is used to drive the equipment directly—as with a chain-saw chain. Other systems use chain or belt drives or have extensions to which other attachments are mounted. You will study mechanical-PTO equipment drives in Unit 2, "Mechanical Drive Systems."

  Figure 2: Mechanical power take-off



- **Hydraulic PTO**

  Note: Some equipment attachments are outfitted with hydraulic motors. The hydraulic motors are driven by hydraulic pumps. These pumps may be driven directly by the engine or by a mechanical PTO. You will learn more about hydraulic-PTO equipment drives in Unit 4, "Hydraulic and Pneumatic Drive Systems."

- **Pneumatic**

  Note: Generally, two types of pneumatic equipment drives are used on power product equipment: (1) the engine can be used to compress air that is stored in a tank, or (2) the movement of gases during the normal engine combustion process can be harnessed to create pressure differentials. Pressure differentials can be used to drive diaphragm pumps and pneumatic motors, similar to the operation of diaphragm fuel pumps. You will also study more about pneumatic-PTO equipment drives in Unit 4.

Information Sheet

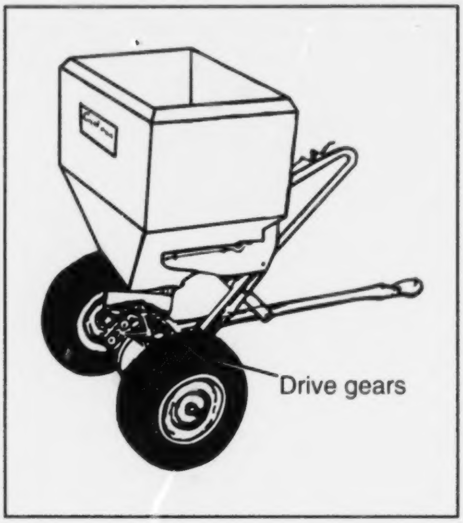
- **Electric**

  Note: Electric equipment drives are simply electric motors that are used to drive equipment. The engine is used to drive the electric motor or is used to drive an alternator or generator that then provides electrical output to equipment. This latter arrangement is commonly used for portable generators and welding equipment, which you will study in *Power Product Equipment Technician: Construction Equipment.*

- **Ground drive**

  Note: Ground-drive equipment-drive systems do not receive power directly from the engine. Instead, the equipment is driven by the turning of the drive axle. A belt or chain may join the drive axle to the equipment drive, or the two may be connected by a gear train. As the drive axle turns, power is transmitted to the equipment. In some cases, towed attachments such as seed or fertilizer broadcasters and sprinklers use independent ground-drive equipment drives and have no direct connection to the engine or power take-offs (see Figure 3).

  Figure 3: Ground-drive equipment drive



10. **Major components of an equipment drive and their functions**

- **Power source**—Provides the input power necessary to operate the equipment drive

- **Actuator**—Engages or disengages the equipment drive

  Note: The most common types of equipment-drive actuators are clutches for mechanical systems (see Figure 4 on page 11), valves for hydraulic and pneumatic systems, and switches for electrical systems.

- **Power output**—Converts input power to a form usable by the equipment

- **Linkage**—Transmits power from the equipment drive to the equipment

Information Sheet

11. Types of clutch systems and their descriptions

Note: In Objective 5, you learned the function of a clutch is to control the transmission of power from the engine to a drive system. When a clutch is engaged, power can be transmitted from the engine to the drive system; when a clutch is disengaged, power is not transmitted. Just as there are many ways of transmitting energy, there are numerous methods of providing clutch capabilities. Four types of clutches are generally used with power product equipment drive trains and equipment drives, as described in this objective.

- **Mechanical**—The clutch uses belts, chains, gears, or friction surfaces to provide connections between the power source and the drive output.

  Note: A mechanical clutch system is the type most commonly used in power product equipment for both drive trains and equipment drives. Mechanical clutches are frequently used in drive systems that employ other than mechanical means of transmitting power. For example, riding lawn mowers that have hydrostatic transmissions often use mechanical-type clutches to connect or disconnect the engine output to the transmission. Numerous variations in mechanical clutch designs exist, many of which are covered in more detail in Unit 2, "Mechanical Drive Systems."

- **Hydraulic**—A liquid is used to apply or remove the pressure necessary to hold the power source and drive-output components in contact.

  Note: Hydraulic clutches are used almost exclusively in hydraulic drive trains and equipment drives. Hydraulic clutches normally operate through the use of valves that are positioned manually or that open and close automatically in response to pressure changes. For example, a garden tractor may have a hydraulic-lift system. Power from the engine is used to drive a pump that pressurizes the system. When the lift system is engaged, a valve allows hydraulic pressure to be applied to the lift mechanism. Hydraulic clutch systems are explained more fully in Unit 4, "Hydraulic and Pneumatic Drive Systems."

- **Pneumatic**—Changes in air pressure are used to apply or remove the pressure necessary to hold the power source and drive-output components in contact.

  Note: As explained further in Unit 4, there are basically two methods for transmitting force pneumatically: (1) the use of air under pressure or (2) the use of differences in air pressure. Leaf blowers, air compressors, and tube tires are examples of air under pressure used in power product equipment. Diaphragm fuel pumps and lawn-mower discharge systems are examples of the use of differences in air pressure to transmit force. Pneumatic clutch systems are used almost exclusively with pneumatic power-transmission systems and generally employ valves, pistons, and diaphragms to bring about pressure changes to engage or disengage the power source.

- **Electromagnetic**—The clutch engages the drive system by magnetically attaching to a portion of the drive mechanism when electrical power energizes a magnetic portion of the clutch; the clutch disengages the drive system when the electrical power is removed and the clutch is no longer magnetized.

  Note: The convenience of an electromagnet is that it has magnetic properties when electricity is applied and does not have magnetic properties when the electricity is removed. This allows creation of an electromagnetic clutch system that is engaged by applying electrical power to the electromagnet. This type of clutch is used almost exclusively in equipment drives. Note also, because a source of electricity is required, electromagnetic clutches are generally found on the types of power product equipment that have other electrical systems, such as an electric starter.

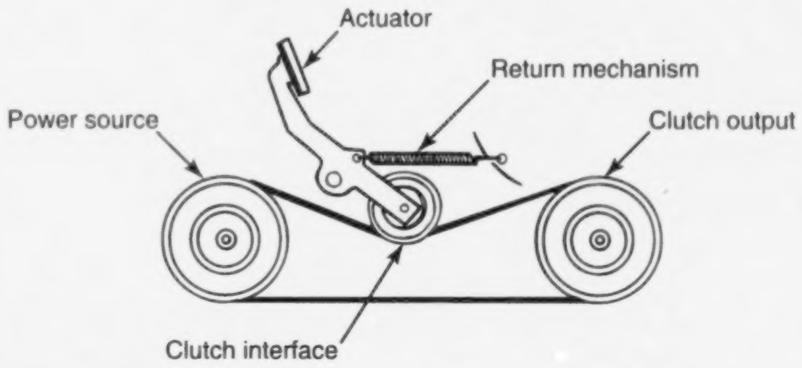
Information Sheet

12. **Major components of a clutch system and their functions** (see Figure 4)

Note: Although there are several types of clutch systems, they all serve the same basic purpose of controlling the transmission of power from the engine to the drive system. Consequently, each type of clutch contains components that do similar tasks to accomplish the purpose of the clutch, whether clutch operation is controlled mechanically, hydraulically, pneumatically, or through electromagnetism. For example, each type of clutch must have a means of engaging or disengaging power transmission and a means of receiving power from the engine. Thus, all clutch systems have four basic elements: (1) an actuator, (2) a linkage to the engine, (3) an output to the drive system, and (4) an interface. Many clutches also have a fifth component that automatically returns the clutch to a desired position.

Figure 4 illustrates a typical clutch system and shows each of the common components. The system shown is a mechanical clutch system that uses a belt and pulleys to link the power source to the drive system. Remember, however, that other mechanical clutch systems may employ a different type of actuator or linkage. Similarly, a hydraulic clutch may use an actuator similar to the one shown and an electromagnetic clutch may use a belt linkage to the drive system. Be aware that the classification of a system is based on the method used to complete the power-transmission path and that other types of power transmission may be involved in the overall system. For example, a clutch engaged through the use of an electromagnet may connect engine power carried by a belt to a pulley on the clutch, to a shaft that turns gears for the power output, to the drive system.

Figure 4: Pedal-actuated clutch



- **Actuator**—Allows the operator to engage or disengage the clutch, or provides automatic control of the clutch

  Note: Numerous methods are used to actuate clutches (see Objective 13).

- **Power source**—Delivers power from the engine

  Note: Output from internal-combustion engines is normally rotary power. However, a clutch system may include components to convert rotary power into some other form—typically reciprocal or linear. The linkage may be mechanical, pneumatic, hydraulic, or some other type of power-transmission path. The linkage may be a fixture on the end of the engine output that mates directly with the clutch (such as a friction plate) or a complex series of belts or gears.

Information Sheet

- **Clutch interface**—Provides the physical connection between the engine-input linkage and the clutch output

  Note: The clutch interface is frequently the component most often thought of as the "clutch" in a clutch system. The clutch interface may be an idler pulley in a belt system, a set of friction plates, the electromagnet in an electromagnetic clutch, or some other device that can mate with the linkage.

- **Clutch output**—Transfers power to the drive system

  Note: The clutch output provides the linkage to the drive system, whether that system is a drive train or an equipment drive. As with the engine-input linkage, the clutch output may be as simple as a direct link between the clutch interface and the drive system, or it may be as complex as a path involving transmissions, differentials, drive axles, and other components.

  You should also be aware that the engine-input linkage and the clutch output may be no more than sections of the same component. For example, some belt-drive systems have a single belt that connects the engine output to the drive system. Such systems may use an idler pulley as a clutch. In this case, the belt is the transmission. The part of the belt between the engine output and the idler pulley is the engine-input linkage, and the part of the belt between the idler pulley and the drive system is the clutch output. You will learn more about this type of clutch and other mechanical systems in Unit 2, "Mechanical Drive Systems." You will learn about hydraulic and pneumatic clutches in Unit 4, "Hydraulic and Pneumatic Drive Systems."

- **Return mechanism**—Returns the clutch to its normal position when the actuator is released

  Note: Many clutches use a spring or other mechanical device to hold the clutch in the engaged position. Actuators disengage the clutch by overcoming the pressure exerted by the return mechanism so that the clutch engages again when the actuator is released. In other designs, a mechanical device holds the clutch disengaged, as with a centrifugal clutch in a chain saw. When the force that engages the clutch is released, the spring or other device disengages the clutch.

13. **Devices used to actuate clutches**

- **Pedal** (see Figure 4 on page 11)

  Note: Pedals are actuated by the operator's foot. Pedals are generally used with self-propelled equipment and are often integrated with the brake system so that one pedal actuates both.

- **Lever**

  Note: Levers are hand-operated devices. Levers are frequently used on riding lawn mowers and garden tractors to engage and disengage mower drive systems and other PTOs. Levers are often used on tillers and snow blowers to engage or disengage equipment drives. Motorcycles frequently have clutch levers mounted to the handlebars.

- **Switch**

  Note: Switches are generally electrical devices used in conjunction with electromagnetic clutches. However, switches can also be control devices for hydraulic and pneumatic systems; these devices are used to position valves or to electrically control the opening and closing of valves or the operation of electrical motors.

Information Sheet

- **Automatic actuating devices**

  Note: The actuating devices discussed previously are controlled by the equipment operator. In some systems, clutches engage and disengage automatically, as controlled by other factors. For example, most centrifugal clutches are automatic; they engage when the engine speed is high enough for centrifugal force to lock the engaging mechanism in place.

Principles of Power Transmission
Unit 1

Assignment Sheet 1—Determine Power-Transmission Characteristics of Power Product Equipment

Name ______________________ Date ______________

Evaluation criteria	**Rating**
Directions have been followed.	______
Minimum of 85 percent of answers are correct.	______
Overall rating	______

Evaluator's comments ______________________________________

____

____

Introduction

Numerous methods are used to transmit and control power between the equipment engine and other systems. These different methods result in great variations in the design, configuration, and specifications for power-transmission systems. The competent technician recognizes these differences and understands how these differences affect performance and service. This understanding comes through experience in working with a variety of types of equipment and their service manuals. In this assignment sheet, you will become acquainted with the power-transmission designs of several types of equipment. You do not need to understand the details of these designs or the purpose of each type of equipment as these details will be covered in future units.

Exercise

Directions

Using the resources available in your facility, answer each of the following questions. Write your answer on the blank provided below each question.

1. Answer the following questions for a John Deere Model 300-series garden tractor.

   a. What method of power transmission is used—mechanical, hydraulic, or hydrostatic?

   ____

   b. Does the equipment have reverse-drive capability?

   ____

Assignment Sheet 1

c. Is the equipment configured with a transmission or a transaxle?

____

d. How many speeds are used with the transmission or transaxle?

____

e. What type of clutch system is used with the equipment drive?

____

f. How is the clutch for the equipment drive actuated?

____

2. Answer the following questions for a Ford LGT14 garden tractor.

a. What method of power transmission is used—mechanical, hydraulic, or hydrostatic?

____

b. Does the equipment have reverse-drive capability?

____

c. Is the equipment configured with a transmission or a transaxle?

____

d. How many speeds are used with the transmission or transaxle?

____

e. What type of clutch system is used with the equipment drive?

____

f. How is the clutch for the equipment drive actuated?

____

3. Answer the following questions for a Honda 3810 garden tractor.

a. What method of power transmission is used—mechanical, hydraulic, or hydrostatic?

____

b. Does the equipment have reverse-drive capability?

____

Assignment Sheet 1

c. Is the equipment configured with a transmission or a transaxle?

____

d. What is the oil capacity and what type of fluid is recommended for the transmission or transaxle?

____

e. What type of clutch system is used with the equipment drive?

____

f. How is the clutch for the equipment drive actuated?

____

4. Answer the following questions for an MTD Model 406 tiller.

   a. What kind of clutch is used with this tiller?

   ____

   b. What mechanism is used to transfer power from the engine to the drive axle?

   ____

   c. What mechanism is used to transfer power from the drive sprocket to the tines?

   ____

   d. How is reverse capability accomplished?

   ____

   e. What type of actuator is used for the clutch?

   ____

Mechanical Drive Systems
Unit 2

Objective Sheet

Unit objective

After completing this unit, the student should be able to describe the design and operation of mechanical drive systems and perform routine maintenance and service procedures on these systems. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific objectives

After completing this unit, the student should be able to

1. List the types of belts used in mechanical drive systems.
2. List the types of chains used in mechanical drive systems.
3. Label the types of gears used in mechanical drive systems.
4. Describe the types of shafts used in mechanical drive systems.
5. Label the types of mechanical drive trains.
6. State the functions of the major components of belt drive trains.
7. Complete statements about the principles of operation of belt drive trains.
8. State the functions of the major components of gear drive trains.
9. Complete statements about the principles of operation of gear drive trains.
10. Label the types of mechanical equipment drives.
11. Complete statements about the principles of operation of mechanical-PTO equipment drives.
12. Complete statements about the principles of operation of ground-drive equipment drives.
13. List typical service procedures required for belt drive systems.
14. List typical service procedures required for chain drive systems.
15. List typical service procedures required for gear drive systems.
16. List typical service procedures required for shaft drive systems.
17. Label types of mechanical clutch systems.
18. Describe the principles of operation of belt clutch systems.
19. Describe the principles of operation of jaw clutch systems.

Objective Sheet

20. Describe the principles of operation of friction clutch systems.

21. Describe the principles of operation of centrifugal clutch systems.

22. Describe the principles of operation of multi-disc clutch systems.

23. State safety rules for working with mechanical clutch systems.

24. List typical service procedures required for mechanical clutch systems.

25. Determine mechanical drive-train service specifications and parts requirements. (Assignment Sheet 1)

26. Determine mechanical equipment-drive service specifications and parts requirements. (Assignment Sheet 2)

27. Determine mechanical clutch-system service specifications and parts requirements. (Assignment Sheet 3)

28. Perform routine maintenance on mechanical drive trains. (Job Sheet 1)

29. Repair mechanical drive trains. (Job Sheet 2)

30. Perform routine maintenance on mechanical equipment drives. (Job Sheet 3)

31. Repair mechanical equipment drives. (Job Sheet 4)

32. Perform routine maintenance on mechanical clutch systems. (Job Sheet 5)

33. Repair mechanical clutch systems. (Job Sheet 6)

Mechanical Drive Systems
Unit 2

Information Sheet

1. Types of belts used in mechanical drive systems

Note: Belts are loops usually made of rubber reinforced with fabric, wire, fiberglass strands, or some other material. Belts provide a mechanical link in many drive trains and equipment drives. The three belt designs most commonly used in power product equipment applications are shown in Figure 1. See Student Supplement 1, "Mechanical Gears, Belts, and Chains" for a more complete discussion of the types of belts used in mechanical drive systems.

- **V-belt** (see Figure 1-a)

  Note: V-belts are one of the most commonly used means of transmitting force in power product equipment. The V-belt most commonly used is the standard V-belt shown in Figure 1-a; however, some V-belts are manufactured with notches along their inside surface to provide greater flexibility. Notched V-belts should not be confused with the cogged belts shown in Figure 1-c.

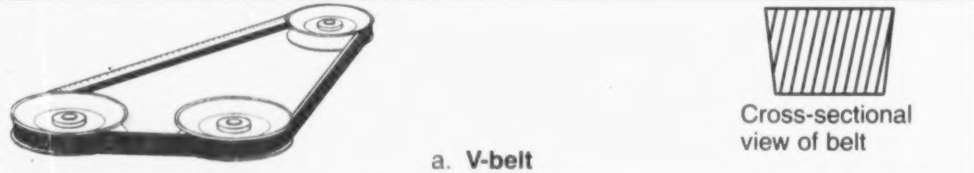
- **Flat belt** (see Figure 1-b)

  Note: Flat belts are roughly rectangular in cross-section (see Figure 1-b). Flat belts ride on flat-surfaced pulleys, and one of the primary reasons a flat belt is used is that an equipment design requires the belt to be routed so that both sides of the belt drive pulleys.

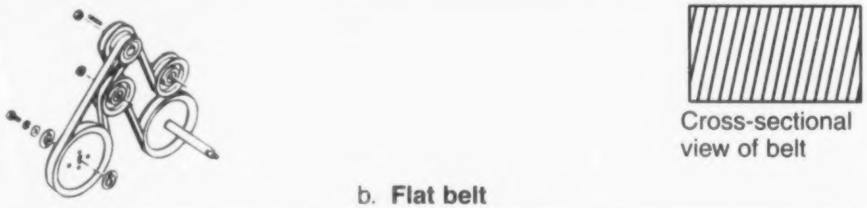
- **Cogged belt** (see Figure 1-c)

  Note: The underside of a cogged belt has a series of evenly spaced indentations (see Figure 1-c). The drive pulley has corresponding teeth that mesh with those on the belt. Cogged belts are designed to provide operation without slippage and are used primarily to provide timing among moving components.

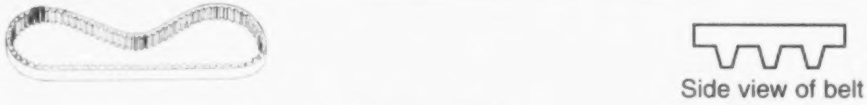
Figure 1: Types of belts used in mechanical drive systems



a. **V-belt**



b. **Flat belt**



c. **Cogged belt**

Figure 1-b reproduced by permission of Simplicity Manufacturing, Inc., Port Washington, Wisconsin.

Information Sheet

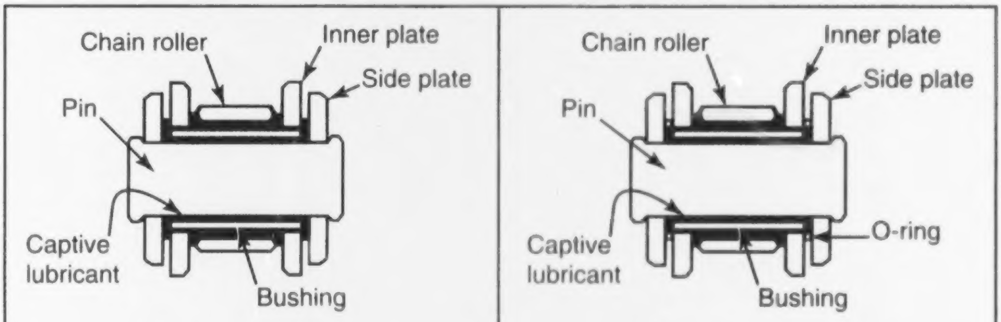
2. Types of chains used in mechanical drive systems

Note: The chains used in mechanical drive systems provide a mechanical link in drive trains and equipment drives in much the same way as the belts described in Objective 1—the indentations in the chain mesh with the teeth of a pivoting sprocket. The two types of chains commonly used in mechanical drive systems are shown in Figure 2. See Student Supplement 1, "Mechanical Gears, Belts, and Chains" for a more complete discussion of the chains used in mechanical drive systems.

- **Double roller** (see Figure 2-a)
- **O-ring** (see Figure 2-b)

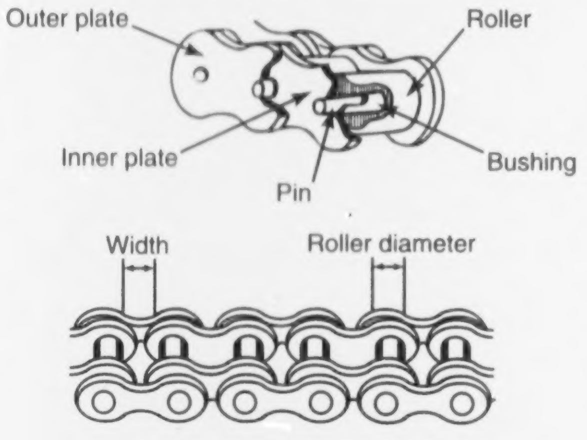
Note: As shown in Figures 2-a and 2-b, the major difference between O-ring and double-roller chains is the O-ring is used to help seal the lubricant in O-ring designs. Figure 2-c shows further details of chain construction. O-ring chains are generally more expensive than standard double-roller chains and are more frequently used for motorcycles as opposed to garden equipment.

Figure 2: Types of chains used in mechanical drive systems


Chain roller
Inner plate
Side plate
Pin
Captive lubricant
Bushing
Chain roller
Inner plate
Side plate
Pin
O-ring
Captive lubricant
Bushing

a. **Cross-section of a double-roller chain**

b. **Cross-section of an O-ring chain**


Outer plate
Roller
Inner plate
Bushing
Pin
Width
Roller diameter

c. **Details of chain construction**

Figures 2-a and 2-b reproduced from: **The Complete Motorcycle Book** by Jim Bennett, Copyright (c)1995 by Jim Bennett. Reprinted by permission of Facts On File, Inc.

Information Sheet

3. Types of gears used in mechanical drive systems

Note: The gears listed below and shown in Figure 3, although used in mechanical drive systems, are also often used in other applications in power product equipment. See Student Supplement 1, "Mechanical Gears, Belts, and Chains" for a more complete discussion of the types of gears used in mechanical drive systems.

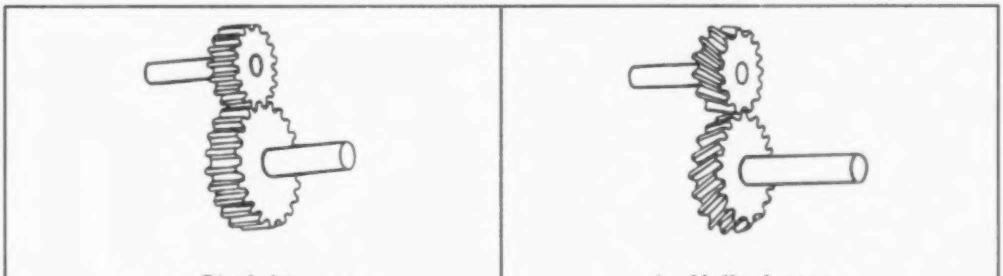
- **Straight** (spur) (see Figure 3-a)
- **Helical** (see Figure 3-b)

  Note: The teeth of helical gears are set at an angle, rather than perpendicular to the face of the gear as are straight gears.

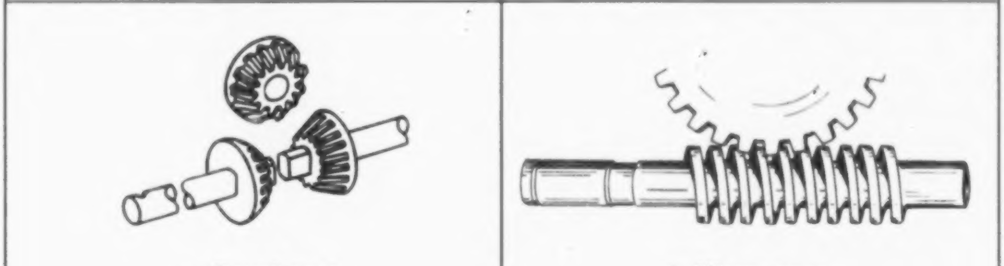
- **Bevel** (see Figure 3-c)
- **Worm** (see Figure 3-d)

  Note: Worm gears derive their name from the spiral "tooth" that wraps around a rod (see Figure 3-d).

Figure 3: Types of gears used in mechanical drive systems



a. **Straight gear** b. **Helical gear**



c. **Bevel gear** d. **Worm gear**

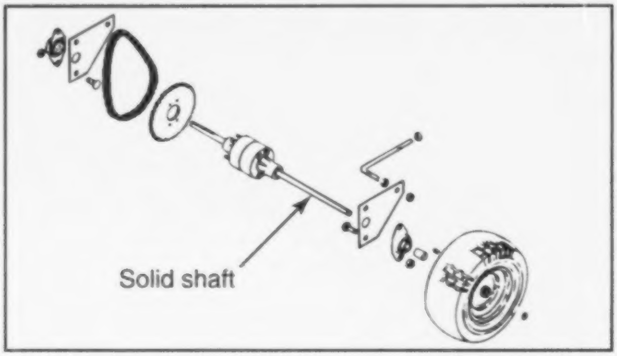
4. Types of shafts used in mechanical drive systems and their descriptions

- **Solid shaft**—Shaft that consists of a single piece

  Note: A solid shaft (see Figure 4 on the next page) is most often used for drive axles and short attachments to equipment where the distance and angle between the connected components does not change much.

Information Sheet

Figure 4: Mechanical drive system with a solid shaft



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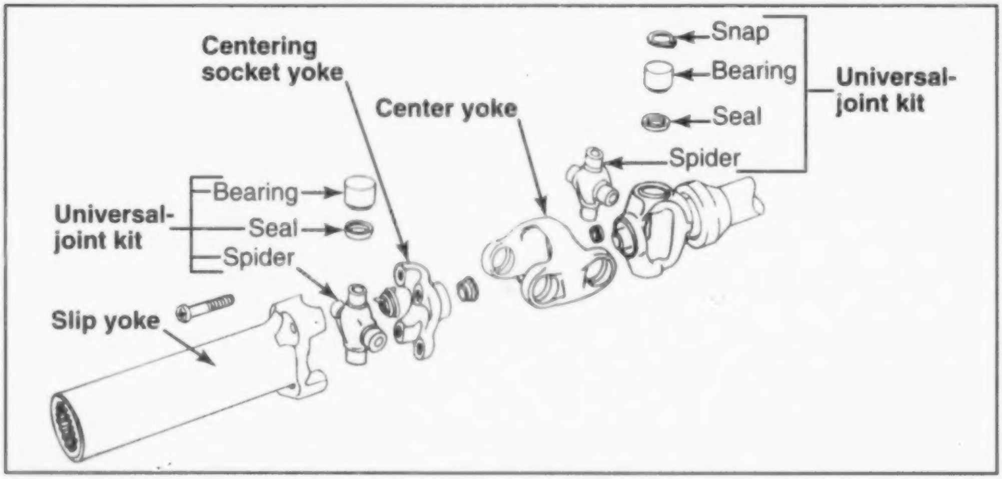
- **Jointed shaft**—Shaft that consists of two or more pieces (see Figure 5), and each piece is joined to the next piece with a universal joint (U-joint)

Note: A U-joint is a mechanical device that allows the shaft to rotate and also remain flexible as the vehicle drives over uneven terrain or makes turns.

Figure 5: Mechanical drive system with a jointed shaft



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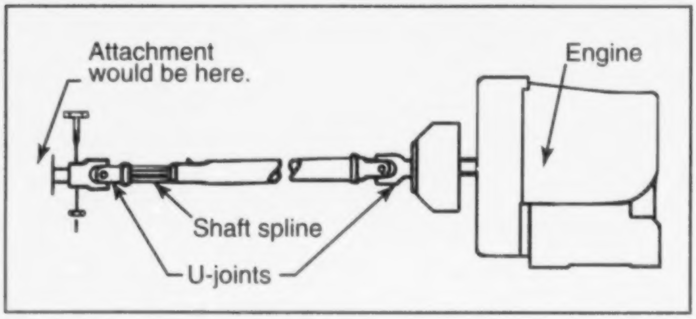
- **Telescoping shaft**—Shaft that consists of two pieces (see Figure 6), one of which slides into the other

Note: Generally, the two pieces of a telescoping shaft have mating splines so that they turn as a single unit yet still move along their center axis. The shaft's telescoping ability allows the length of the shaft to adjust as the distance between the connected parts changes when the vehicle travels over uneven ground, and it also allows for easier installation when a technician aligns the shaft with its mating components.

Information Sheet

Figure 6: Mechanical drive system with a telescoping shaft


Attachment would be here.
Engine
Shaft spline
U-joints

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5. Types of mechanical drive trains

Note: As you learned in Unit 1, a transmission or a transaxle is the output configuration used in drive trains. A transmission is an output configuration that transfers engine power to the final drive at one or more speeds and often in forward and reverse directions. A transaxle is an output configuration that transfers engine power directly to the drive wheels.

A mechanical drive train may use either a transmission or a transaxle, but the most common types of mechanical drive trains used in power product equipment are belt-driven transmissions and gear-driven transmissions. A mechanical transmission may be as simple as a single belt and pulley driven by a pulley on the engine shaft or as complex as a separate component with several gears and shafts that allow control of both speed and direction.

- **Belt drive train** (see Figure 7)
- **Gear drive train** (see Figure 8 on the next page)

Figure 7: Typical belt drive train

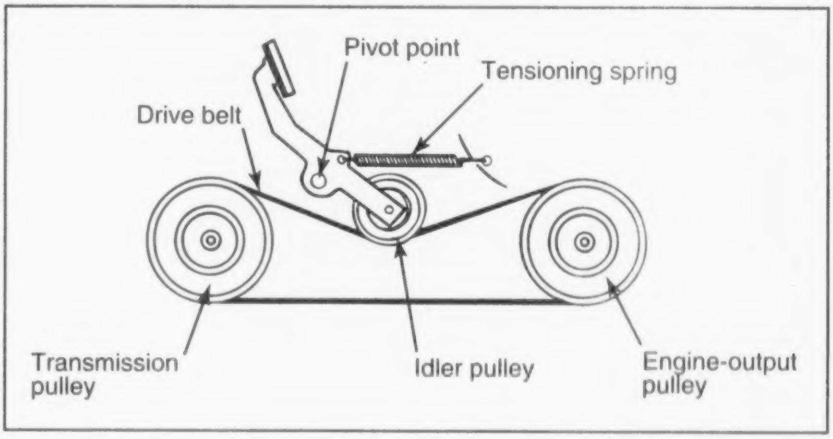
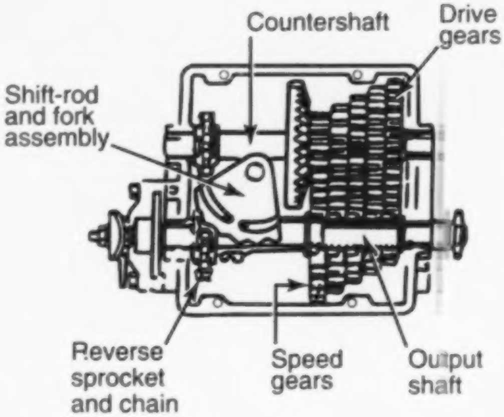

Pivot point
Tensioning spring
Drive belt
Transmission pulley
Idler pulley
Engine-output pulley

Figure 8: Typical gear drive train



Note: The pinion gear and input shaft are not visible in this drawing.

6. **Major components of belt drive trains and their functions** (see Figure 7 on page 25)

    - **Engine-output pulley**—Provides rotary power from the engine

        Note: Normally, the engine-output pulley is mounted on an extension of the crankshaft. However, in some applications the camshaft is used, and in other applications both the crankshaft and the camshaft are used. When both the crankshaft and camshaft are used, one output is for the drive train and the other for the equipment drive, or one is used for forward and the other for reverse.

    - **Drive belt**—Transmits power from the engine-output pulley

        Note: The drive belt may serve only the drive train, or it may also serve an equipment drive.

    - **Idler pulley** (tension idler pulley)—Increases or releases tension on the drive belt

        Note: In a belt-driven mechanical drive train, the idler pulley serves as a clutch for the drive line. In some designs, the pulley can swivel in two directions so that one direction provides forward motion and one direction provides reverse motion. The position where the pulley is not engaged is called *neutral*.

    - **Transmission pulley**—Provides power input to the final drive

        Note: The final drive is the part of the drive train that makes contact with the ground to propel the equipment. Power may also be directed to equipment drives.

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7. Principles of operation of belt drive trains

Note: The statements below describe how power is transmitted when the system is engaged (see Figure 7 on page 25).

- Rotary motion from the engine crankshaft is transferred to the engine-output pulley, which is mounted on the crankshaft.
- As the idler pulley applies tension to the drive belt, the engine-output pulley transmits power to the drive belt, which loops around one or more transmission pulleys or to the drive axle.

  Note: Some equipment designs use a variable pulley that changes diameter to regulate the force that is transmitted.

8. Major components of gear drive trains and their functions (see Figure 8 on page 26)

Note: A gearbox is a housing with gears that work together to perform a common function. Typically, gear drive trains consist of gearboxes configured as transmissions or transaxles. Equipment with a gear drive train may have only a single gear (or single speed), or it may have multiple gears (multiple speeds). In equipment with multiple gears, the gears are offset in such a way that the operator must position a control lever to shift from one gear (or speed) to another. Multiple-gear drive trains are, therefore, often called *multiple-speed manual transmissions* or *transaxles*.

- **Input shaft**—Brings power from the engine into the transmission

  Note: The input shaft normally connects to the clutch output either directly or through a mechanical means such as a belt or gear train.

- **Pinion gear**—Transmits power to the countershaft and changes the direction of rotational force

  Note: In most power product equipment, the transmission sits either to the rear of the engine or in front of the engine. The engine-output shaft and the transmission-input shaft are generally placed parallel to each other, which means that the direction of the power must be changed to drive the countershaft. This change of direction is accomplished by the pinion gear.

- **Countershaft**—Holds the drive gears
- **Drive gears**—Transmit power to the speed gears
- **Shift-rod and fork assembly**—Positions the speed gears in relation to the drive gears to vary the output-gear ratio or to vary the direction of travel
- **Speed gears**—Transfer power to the output shaft
- **Reverse chain**—Drives the output shaft in the opposite direction of the speed gears

  Note: When two shafts are connected by a chain, the drive sprocket and driven sprocket rotate in the same direction. If two gears mesh, the driven gear turns in the opposite direction of the drive gear. These principles can be used to configure the drive train so that the output can be forward or reverse.

- **Reverse sprocket**—Meshes with the reverse chain to change the direction of rotation of the output shaft

- **Output shaft**—Provides power to the final drive

  Note: For gear drive trains with a transmission, the output shaft usually mates with the differential, which then feeds power to the drive axles. In gear drive trains with a transaxle, the differential is internal and the drive axles extend from the transaxle.

9. **Principles of operation of gear drive trains**

   Note: The following description applies specifically to a multiple-speed drive train and describes how power is transmitted when the system is engaged (see Figure 8 on page 26). However, the principles described generally apply to other configurations of transmissions and transaxles.

   - Rotary motion from the engine crankshaft is transferred to the transmission input shaft.
   - The input shaft causes the countershaft to rotate, which turns the drive gears.
   - The shift-rod and fork assembly is positioned by the operator to control the arrangement of gears so that a selected speed gear meshes with its drive gear.
   - Power transferred through the transmission exits along the output shaft with a linkage to the differential.

     Note: The linkage may be a chain, belt, shaft, or set of gears.

   - The power from the transmission drives the gears of the differential.

     Note: A differential is a gearbox that allows the drive wheels to turn at different speeds and that may be used to change the direction of transmission output to the drive axle.

   - The differential turns the drive axles, which turn the drive wheels to propel the vehicle.

     Note: The gears of the differential are designed to rotate at different speeds when the vehicle is turning; the wheel toward the center of the turn rotates slower than the wheel that is farther away from the center of the turn.

     In transaxle designs, the transmission and differential are combined into a single unit with the transaxle output directed along the drive axles.

10. **Types of mechanical equipment drives**

    - **Mechanical PTO** (see Figure 9-a on the next page)
    - **Ground drive** (see Figure 9-b on the next page)

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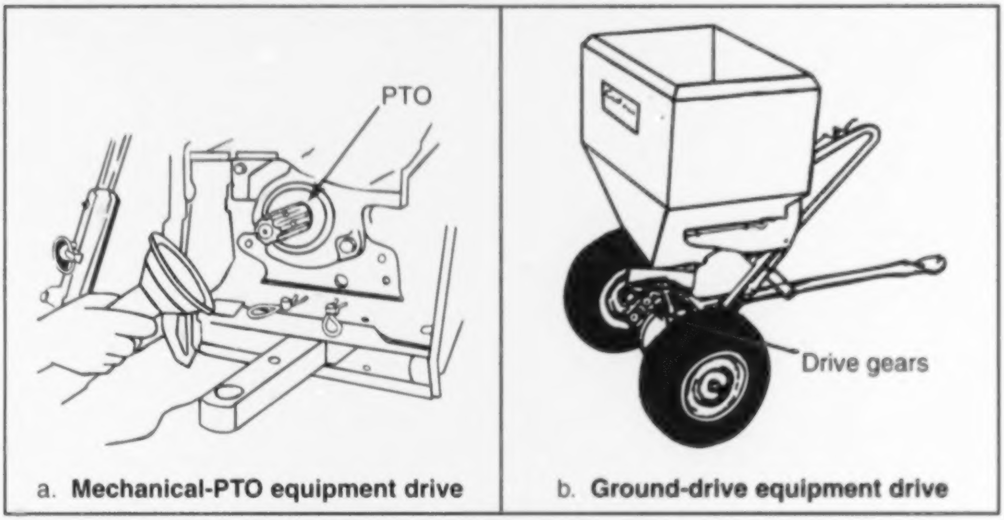
Figure 9: Types of mechanical equipment drives



a. **Mechanical-PTO equipment drive**

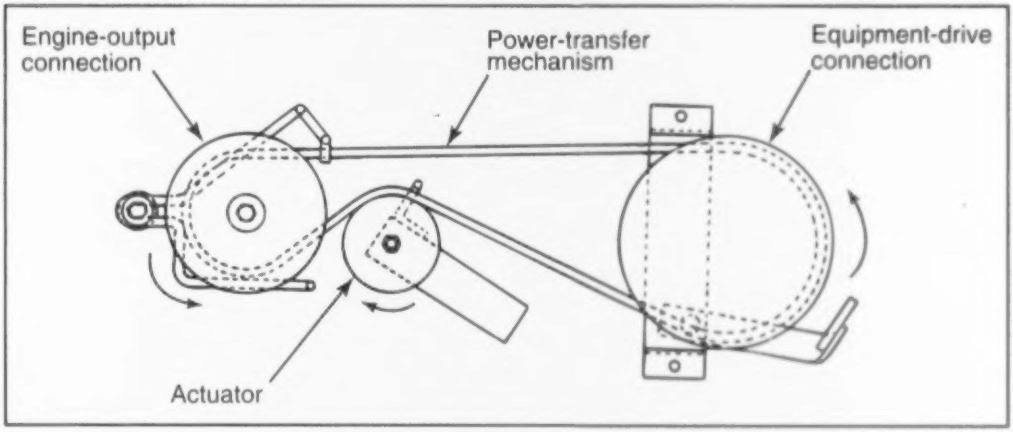
b. **Ground-drive equipment drive**

11. **Principles of operation of mechanical-PTO equipment drives** (see Figure 10)

Note: The exact components of a specific mechanical equipment drive will vary from one type of equipment drive to another. However, all mechanical equipment drives serve the same purpose: to transfer force from a power source (the engine, a turning wheel, or compressed air) to a power-equipment device (blade, winch, or blower fan). A belt-driven equipment drive is shown in Figure 10 to illustrate the basic components described in the statements below.

- The engine-output shaft turns a gear, pulley, or shaft.
- The gear, pulley, or shaft drives a belt, chain, or gear (power-transfer mechanism) to transfer rotary power to the equipment.

Figure 10: Transfer of force from a power source to a power-equipment device



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12. Principles of operation of ground-drive equipment drives

Note: The statements below apply to equipment that is self-powered or moved by another source of power.

- The turning of an axle produces rotary power in the axle without a link between that axle and the engine.
- The rotary power is transferred by gears, belts, or other mechanical means to power the equipment.

13. Typical service procedures required for belt drive systems

Note: Remember, the term *drive systems* applies to both equipment drives and drive trains.

- Adjust belt tension
- Replace belt
- Align pulley
- Replace pulley
- Lubricate spindle and pulley bearings

  Note: A spindle is an extended shaft that may have more than one pulley or that may be extended just to allow better alignment of the input and output pulleys.

- Adjust actuating mechanism

14. Typical service procedures required for chain drive systems

- Adjust chain tension
- Replace chain links
- Replace chain
- Align chain
- Replace sprockets
- Lubricate spindles and shafts
- Adjust actuating mechanism

15. Typical service procedures required for gear drive systems

- Adjust gear alignment
- Replace gears
- Replace gear shafts

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- Lubricate gears and shafts
- Adjust engagement mechanism

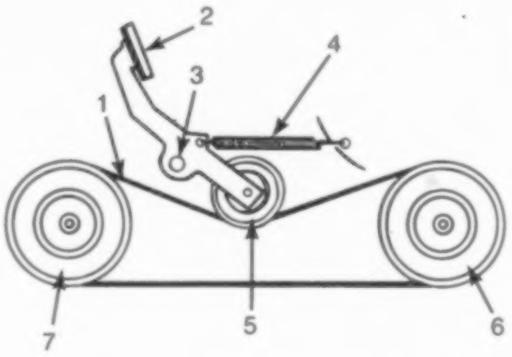
16. **Typical service procedures required for shaft drive systems**

- Adjust shaft length
- Replace shaft
- Lubricate shafts and joints
- Replace joints
- Adjust actuating mechanism

17. **Types of mechanical clutch systems**

- **Belt** (see Figure 11)
- **Jaw** (see Figure 12 on the next page)
- **Friction** (see Figure 13 on the next page)
- **Centrifugal** (see Figure 14 on page 33)
- **Multi-disc** (see Figure 15 on page 33)

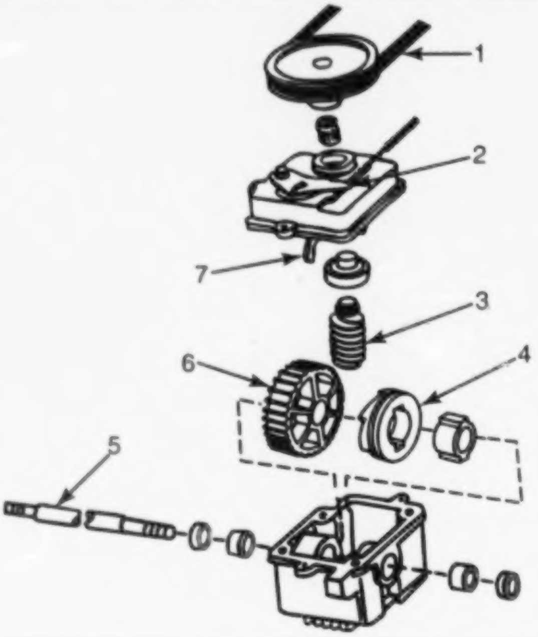
Figure 11: Belt clutch



1. Belt
2. Clutch pedal
3. Pivot point
4. Engaging spring
5. Idler pulley
6. Engine pulley
7. Drive pulley

Information Sheet

Figure 12: Jaw clutch



1. Belt
2. Clutch control lever
3. Worm gear
4. Jaw clutch
5. Shaft
6. Drive gear
7. Shift fork

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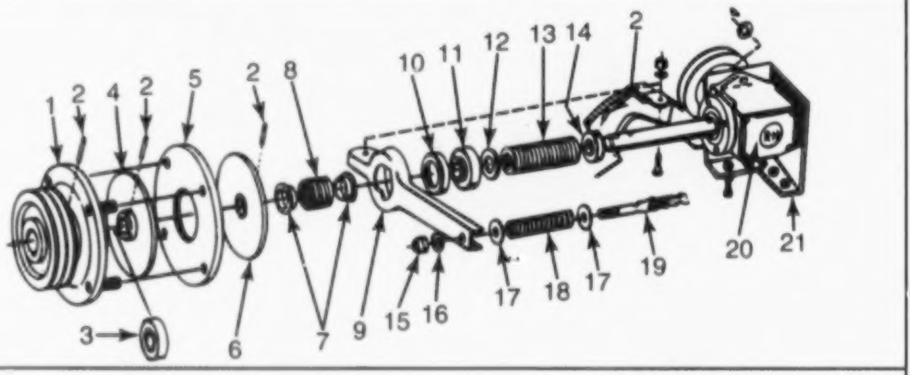
Figure 13: Friction clutch



1. PTO drive and adapter
2. Roll pins
3. Bearing
4. Outer disc
5. Pressure plate
6. Inner disc
7. Spring guide
8. Spring
9. Clutch arm
10. Bearing cover
11. Bearing
12. Washer
13. Spring
14. Collar
15. Adjusting nut
16. Washer
17. Washer
18. Spring
19. Rod and chain
20. Right-angle drive unit
21. Bracket

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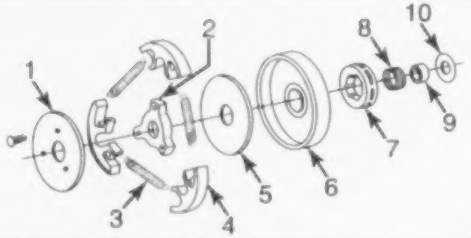
Figure 14: Centrifugal clutch



1. Cover plate
2. Hub
3. Spring
4. Shoe
5. Washer
6. Clutch drum
7. Sprocket
8. Bearing
9. Inner race
10. Washer

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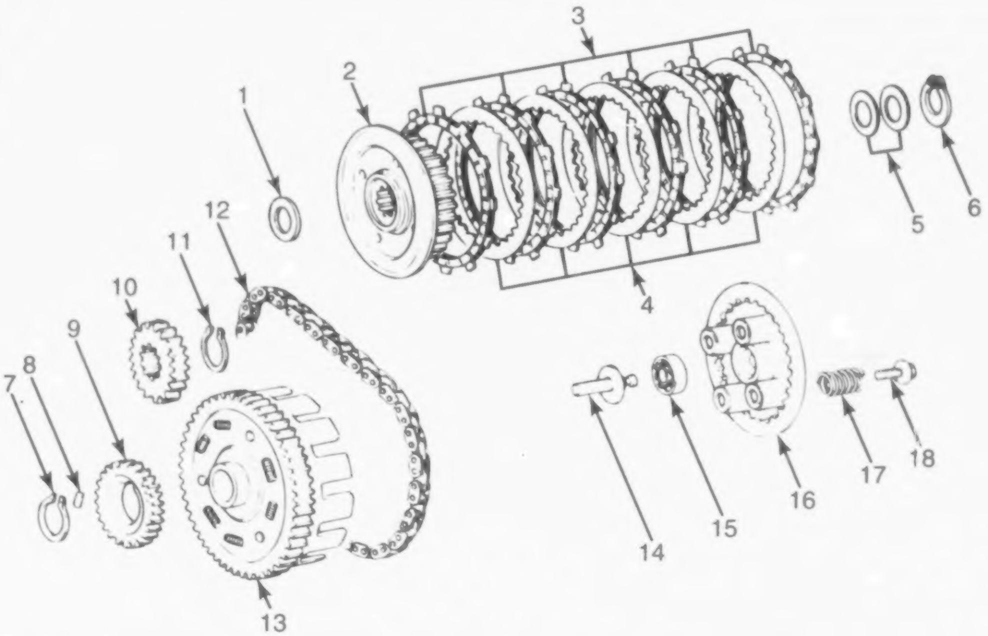
Figure 15: Multi-disc clutch



1. Thrust washer
2. Clutch hub
3. Friction plates
4. Steel plates
5. Shim(s)
6. Circlip
7. Circlip
8. Pin
9. Oil-pump drive gear
10. Primary sprocket
11. Circlip
12. Primary chain
13. Clutch housing
14. Spring-plate pusher
15. Ball bearing
16. Spring plate
17. Spring
18. Bolt

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18. **Principles of operation of belt clutch systems** (see Figure 11 on page 31)

- **Engine output**—The engine pulley is mounted on the end of the engine crankshaft and turns whenever the engine is running.

- **Power transfer**—A belt is routed over the engine pulley, and the other end of the belt is routed over a drive pulley mounted on the end of the transmission or equipment drive.

- **Clutch engaged**—When the operator releases the clutch actuator, the tension applied by the engaging spring to the idler pulley is strong enough to deflect the belt so that the rotation of the engine pulley moves the belt and causes the drive pulley to turn.

- **Clutch disengaged**—When the operator actuates the clutch, the tension of the engaging spring is overcome, causing the idler pulley to lessen the tension on the belt. With the tension on the belt released, the rotary force of the engine is no longer transferred to the drive pulley.

19. **Principles of operation of jaw clutch systems** (see Figure 12 on page 32)

- **Engine output**—The engine pulley, sprocket, or gear is mounted on the end of the engine crankshaft and turns whenever the engine is running.

- **Power transfer**—A belt, chain, or gear transfers power from the engine member to a corresponding drive member that rotates the drive gear.

  Note: In Figure 12, the belt driven by the engine turns a shaft to the worm gear, which in turn causes the drive gear to rotate.

- **Clutch engaged**—When the operator releases the clutch actuator, pressure from a lever slides the jaw clutch along a shaft and holds it in contact with the drive gear. In this position, the jaw clutch mates with a gear, collar, or other structure on the shaft of the drive train or equipment drive so that the rotation of the drive gear is transferred to the jaw clutch and then to the drive shaft.

- **Clutch disengaged**—When the operator actuates the clutch, the lever moves from the jaw clutch, removing the pressure that holds the jaw clutch engaged with the drive gear, thus breaking the linkage to the engine output.

  Note: While springs or other devices are sometimes used to disengage the jaw clutch from the drive gear, the centrifugal force of the rotating drive gear is generally sufficient to break the connection once clutch pressure is removed.

20. **Principles of operation of friction clutch systems** (see Figure 13 on page 32)

Note: There are numerous friction-clutch designs. The major difference among the designs is the shape of the friction surface. The four most common shapes of friction surfaces used on power product equipment clutches are the disc, the external band, the internal band (normally called *shoes*), and the cone. The description below applies to each type of friction surface.

- **Engine output**—A friction surface is mounted to the end of the engine crankshaft and turns whenever the engine is running.

- **Power transfer**—A second friction surface is mounted to the drive shaft of the transmission or equipment drive.

  Note: The second friction surface may be mounted directly to the drive shaft or to a pulley, sprocket, or gear that is used to transmit power to the drive shaft.

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- **Clutch engaged**—When the operator releases the clutch actuator, the pressure of the engaging spring is strong enough to hold the two friction surfaces in contact so that the rotation of the engine friction surface causes the drive shaft to turn.
- **Clutch disengaged**—When the operator actuates the clutch, the pressure of the engaging spring is overcome, causing the friction surfaces to separate. With the friction surfaces separated, the rotary force of the engine is no longer transferred to the drive shaft.

21. **Principles of operation of centrifugal clutch systems** (see Figure 14 on page 33)

Note: Centrifugal clutches are used primarily for equipment drives to allow the engine to start without a load. Once the engine starts and reaches the required rpm, the equipment drive is automatically engaged.

- **Engine output**—The clutch shoes are mounted on the end of the engine crankshaft and turn whenever the engine is running.
- **Power transfer**—The rotation of the clutch-shoe assembly creates centrifugal force, which causes the shoes to spread outward against the tension of the springs.
- **Clutch engaged**—When the engine speed is fast enough, the shoes contact the drum and, through friction, cause it to turn. The drum is connected to a shaft, pulley, gear, or sprocket that transfers rotary motion to the drive line or equipment drive.
- **Clutch disengaged**—When the engine slows, the tension of the springs overcomes centrifugal force and pulls the shoes away from the drum. With the shoes disengaged, the rotary force of the engine is no longer transferred to the drum.

22. **Principles of operation of multi-disc clutch systems** (see Figure 15 on page 33)

Note: A multi-disc clutch system functions in much the same way as a friction clutch that uses friction discs. The difference in the two types of clutch systems lies largely in the number of discs used. Where a typical friction system uses a pair of discs, a multi-disc clutch system uses three or more discs and is generally found on heavy-duty applications, such as motorcycles or all-terrain vehicles.

Disc clutches can be classified as either wet or dry clutches. Wet clutches use an oil spray or bath to cool the clutch. Dry clutches are air cooled. The two types of clutches use very different materials that cannot be interchanged. For example, a dry disc can be damaged if it is contaminated by oil.

- **Engine output**—A friction disc is mounted to the end of the engine crankshaft and turns whenever the engine is running.
- **Power transfer**—A second friction surface is mounted to the drive shaft of the transmission or equipment drive.
- **Clutch engaged**—When the operator releases the clutch actuator, the pressure of the engaging spring is strong enough to hold the two friction surfaces in contact so that the rotation of the engine friction surface causes the drive shaft to turn.
- **Clutch disengaged**—When the operator actuates the clutch, the pressure of the engaging spring is overcome, causing the friction surfaces to separate. With the friction surfaces separated, the rotary force of the engine is no longer transferred to the drive shaft.

23. Safety rules for working with mechanical clutch systems

- **Check to see whether clutch components contain asbestos, and if so, follow your facility's asbestos-handling procedures.**

  Note: Asbestos has been shown to be a cancer-causing agent, especially when the dust is inhaled. While asbestos has been eliminated from current manufacture in the United States, older products and some foreign-made clutch friction plates may contain asbestos. Do **not** allow dust from such components to escape into the air.

- **Be careful when working with clutch springs; they may become flying objects if they become disengaged or break.**

  Note: Any component that is placed under pressure may break or slip as a result of that pressure. The broken pieces or the part itself can be thrown through the air with enough force to cause serious injury.

- **Never work on a clutch when the engine is operating.**

  Note: Even if the clutch is not engaged, there is usually only a small distance between the engaged and disengaged positions. It is easy to push against a belt or to slip a tool between friction plates. When this happens, power is transferred to the clutch. The resulting force is likely to throw tools or loose parts into the air. Also, moving parts may injure a technician's fingers or catch his or her clothing.

- **Check clutch components for cracked or frayed belts, cracked or delaminated friction surfaces, and any deterioration that may have occurred during operation.**

  Note: Clutch parts undergo tremendous pressures and high temperatures as well as sudden changes in forces as they engage and disengage. For these reasons, weak parts are likely to fail. Part failures are very dangerous as the system virtually explodes—belts or pieces of belts, clutch plates, springs, centrifugal weights, jaws, and gears are thrown from the clutch system. One particular defect that is possible is the delamination of friction surfaces. Delamination refers to a separation in a layered structure, such as the separation of the friction surface from the brake structure.

- **Do not overtighten parts or apply excessive pressure to springs and belts.**

  Note: Overtightened parts do not operate correctly and are likely to break. Clutch components under excessive pressure overheat and fail.

- **Do not remove safety devices or make them inoperable.**

  Note: Most clutch systems have covers and guides to protect the operator or service technician from the potential dangers of moving parts and flying objects.

- **Be careful not to become entangled in the moving parts of the clutch.**

  Note: Service technicians often forget the dangers presented by the turning shafts of the clutch components, moving belts and chains, and linkages that may shift without warning during equipment operation. These parts may cut or cause abrasions, pinch or crush body parts, or cause other serious injury.

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24. Typical service procedures required for mechanical clutch systems

- Replace belts
- Adjust belt tension
- Replace friction plates
- Replace and align pulleys
- Lubricate bearings
- Replace bearings
- Replace springs and other hardware

Mechanical Drive Systems
Unit 2

Student Supplement 1—Mechanical Gears, Belts, and Chains

Introduction

Virtually every type of power product equipment will use gears, belts, or chains or a combination of these devices. Because the overall purpose of power product equipment is to utilize power from the engine to do some specific type of work, there must be some way of transferring the force of the energy to other parts of the equipment—whether that is to turn a mower blade, drive a generator, power a snowmobile, or mix concrete. These forces are often transmitted along a mechanical train—a series of mechanical parts that direct, regulate, and control the output of the engine. Gears, belts, and chains—and the pulleys, sprockets, guides, and other hardware associated with them—are the most common types of mechanical devices used in power product equipment. This supplement will acquaint you with the design and operation of these devices along with the principles that govern their operation.

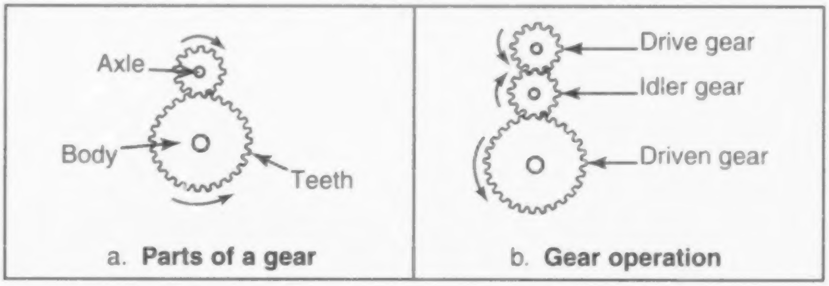
Gears

The gears used in power product equipment engines tend to be fairly simple arrangements with applications such as driving the camshaft or powering an oil slinger. Some engines, however, make greater use of gears and, once the need to transfer power from the engine to other parts of the equipment arises, the use of gears becomes even more common. Gears are frequently used in drive trains, equipment drives, steering systems, electric starters, and other subsystems that require the transfer of rotary power.

Parts of a gear

Because the purpose of a gear is to transfer rotary power, the basic shape of a gear is usually a circle or a cylinder. Gears also tend to have the same basic parts, although specific gears may vary greatly in size and construction. The illustration in Figure 1-a shows the basic parts of a gear. The center of the typical gear is an axle about which the gear turns. The wheel or cylinder portion of the gear is the body. The outside of the body is cut into teeth that come in a variety of shapes, as explained later in this supplement.

Figure 1



a. **Parts of a gear**

b. **Gear operation**

Gear operation

Gears normally operate in pairs or sets referred to as *trains*. The teeth of one gear mesh with the teeth of one or more other gears—that is, the teeth of one gear fit into the teeth of another gear. In any set of gears, one gear is called the *drive gear* or *driver* (see Figure 1-b on page 39). Its axle is connected to a power source, such as the crankshaft of an engine. The rotary output of the power source causes that gear to turn, which then causes any gears with which it meshes to move. Gears that are turned by the drive gear are referred to as *driven gears, slave gears,* or *idler gears.* Their axles are usually connected to another piece of equipment to which the rotary force of the engine is transferred, such as a drive axle or power take-off.

In a train of two gears, the gears turn in opposite directions (see Figure 1-a on page 39). If the drive gear rotates clockwise, then the driven gear will rotate counterclockwise. Thus, not only does a gear train transmit power, it also changes its direction. Sometimes, it is not desirable to have the driven-gear rotation to be opposite the rotation of the drive gear. To allow the drive gear and the driven gear to rotate in the same direction, an idler gear is used (see Figure 1-b on page 39). The drive gear turns the idler gear, which transmits power to the driven gear.

Another aspect of gear operation is the difference in sizes of gears that mesh. In some instances, a pair of gears is the same size, in which case the force output by the driven gear is basically the same as the force input to the drive gear. However, it is often desirable to have the driven-gear output to be different than the input of the power source. This difference in power transfer can be thought of in two ways: (1) the speed of rotation or (2) the amount of force transferred (rotational force). The two characteristics are inseparable, but for the convenience of explaining gear operation, we will consider them separately, beginning with the speed of rotation.

Speed of rotation

It is possible to make the axle of a driven gear turn faster or slower than the speed of the drive gear. This is done by making the driven gear larger or smaller than the drive gear. For example, if the drive gear has 25 teeth and the driven gear has 100 teeth, the drive gear will have to rotate four times to drive the driven gear through one complete rotation. If the rotational speed of the drive gear is 100 revolutions per minute, then the driven gear is going to rotate only 25 times in 1 minute.

In a set of gears, the smaller gear is referred to as the *pinion gear.* If the pinion gear is the drive gear, as in the example above, the speed of rotation is reduced. This kind of relationship is known as a *reducing gear set.*

Now, consider the above example with the roles reversed. Assume the drive gear has 100 teeth and the pinion gear with 25 teeth is the driven gear. In this case, the smaller gear will turn four revolutions for each complete rotation of the drive gear. Thus, the speed is increased. If the drive gear is turning at 100 rpm, then the pinion gear will turn at 400 rpm. Because the speed is increased or multiplied, this relationship is known as a *multiplying gear set.*

As you can see from these examples, the bigger the difference in the number of teeth on the two gears, the greater the difference in their speeds. If the pinion gear has one-fourth as many teeth as the other gear, then its speed will be four times that of the other gear. If the pinion gear has one-tenth as many teeth as the other gear, its speed will be ten times that of the other gear. This relationship is referred to as *gear ratio.* Gear ratios are stated as other ratios, with two numbers separated by a colon or the word *to*, as in *4:1* or *4 to 1*. The ratio in this example means that four turns of the drive gear are converted into one turn of the driven gear. One common practice is to state the drive gear first so that a 5:1 ratio means that the drive gear is the pinion gear and turns five times for every rotation of the driven gear, while a 1:5 ratio means that the pinion gear is the driven gear and that it rotates five times for every rotation of the drive gear.

The ability to change rotational speed by varying gear size can be handy in the operation of power product equipment. Consider a riding lawn mower as an example. The engine operates at a certain rpm and is used to power both the drive train and the mower blade. In all likelihood, engine speed is not the same rotational speed required to turn the wheels and to turn the mower blade. If the blade turned at the speed of the wheels, it would probably be too slow to cut efficiently, and if the wheels turned at the same speed as the blade, the vehicle would probably travel too fast. However, by using different sizes of gears (or pulleys for belt-driven systems and sprockets for chain-driven systems), the force from a single engine rpm can be regulated to an appropriate rotational speed for other uses.

Rotational force

Speed is not always the primary concern. The other characteristic that is regulated when speed is changed is torque. Torque is rotational force. Torque is the product of a force and its distance from the center of an axis. For example, if 10 pounds of force are applied to the teeth of a gear that is 10 inches in diameter, the torque produced will be 100 pound-inches, as computed by the formula:

$$\begin{aligned}\text{Torque} &= \text{Force x distance}\\ &= \text{10 pounds x 10 inches}\\ &= \text{100 pound-inches}\end{aligned}$$

With a little bit of analysis, it becomes apparent that changing a gear ratio to increase speed will decrease torque, while changing the gear ratio to decrease speed will increase torque. This is because speed is reduced by increasing the number of teeth on a gear, which is achieved by increasing its diameter and, thus, increasing torque. Therefore, a large gear will turn at a slower effective speed but will produce more torque. If the pinion gear is the drive gear in a gear set with a 4:1 ratio, the driven gear will turn at one-fourth the speed of the pinion gear but its torque will be four times as great.

Torque can be especially important in driving a piece of power equipment, such as a riding lawn mower, garden tractor, or snowmobile. In a situation with reduced traction, such as icy or wet surfaces, high speeds will not help overcome the loss of traction. The wheels or tracks will simply spin. However, increased torque at low speeds will allow more force to be applied to moving the vehicle and will improve traction.

Gear designs

Because gears are used in various applications, the operational requirements are not always the same and various designs have been developed to meet these varying requirements. Most of the design variations are intended to overcome specific problems or to permit the transfer of force along a specific path. The following paragraphs describe and illustrate some of the more popular gear designs.

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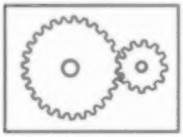
Straight gears (spur gears)

Straight gears have straight teeth that parallel the axis (see Figure 2). Straight gears are used in many applications, especially where speeds tend to be low and do not vary greatly. A straight gear may be a flat disc or a cylinder. Straight gears are often used with worm gears and racks, which are described on the next page.

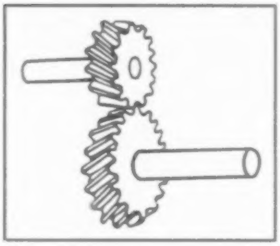
Figure 2: Straight gear



Helical gears

The teeth of a helical gear are set at an angle to the axis (see Figure 3). The advantage of a helical gear over a straight gear is that it runs smoother and quieter at high speeds and provides greater strength for heavy loads. However, the angle of the teeth can lead to sideways deflection of some of the force, resulting in lower efficiency. Some gears are constructed with herringbone teeth—V-shaped teeth centered on the edge of the gear. This design provides the advantages of a helical design while offsetting some of the lateral distortion.

Figure 3: Helical gear



Bevel gears

Often it is desirable to change the direction of force, as in using the engine output to drive both the blade under a mower and the wheels at the side of the mower. One way of changing the angle of the flow of force is to use bevel gears. Bevel gears are cut at an angle, often at 45 degrees so that they form a 90-degree change in the power-transmission path (see Figure 4 on the next page). Bevel gears in differentials and gearboxes frequently have helical teeth. This special configuration is referred to as *hypoid gears.*

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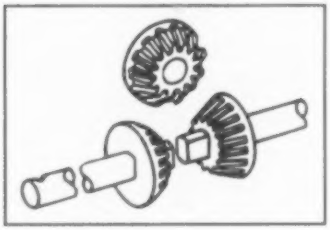
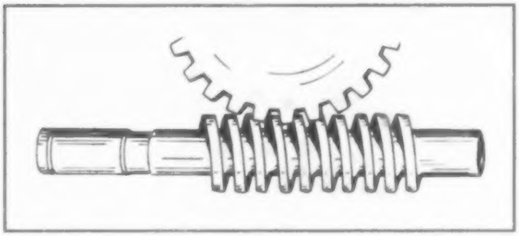
Figure 4: Bevel gear



Worm gears

Another method for changing the direction of force flow so that it is perpendicular to the driver axle is the use of a worm gear. A worm gear is constructed with a spiral tooth running around an axle (see Figure 5).

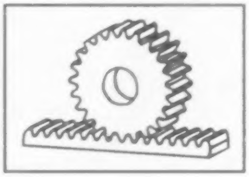
Figure 5: Worm gear



Rack gears

The rotary motion of a gear can also be transformed into lateral movement through the use of a rack gear. A rack gear is a bar with teeth, normally like those of a straight gear. The rack is installed in such a way that the rotation of a second gear causes the rack to move to one side or the other. Thus, the driving gear can rotate in one direction and cause the rack to move to the right or rotate in the other direction to move the rack to the left. The most common application of a rack gear in power product equipment is in steering systems in a design commonly referred to as *rack and pinion* (see Figure 6).

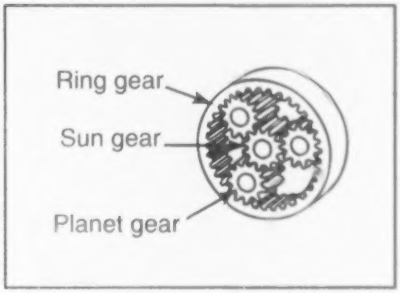
Figure 6: Rack gear



Internal-tooth gears

While most gears have teeth on the outside of their discs, some gears have internal teeth. These teeth mesh with other gears within the body of the internal-tooth gear. These gears are sometimes used in gear trains called *planetary gears* in which several gears are installed within the internal-tooth gear (see Figure 7). This design is sometimes used in mechanical transmissions in power product equipment. Some gears include both internal and external teeth. Gears with hollow bodies—whether they possess internal or external teeth—are often called *ring gears*. In a planetary-gear arrangement such as that shown in Figure 7, the center drive gear is often referred to as a *sun gear*, while the idle gears are called *planet gears*.

Figure 7: Planetary gear



Gear service

Gears are designed to provide smooth, reliable operation with little service. Gears used in power product equipment may be made of a variety of materials, mostly metals and plastics. Some are subject to high temperatures and forces and may require lubrication, which means that routine service may include checking and changing lubricants and filters.

Gears should be inspected for missing or broken teeth and wear during other service procedures. Most gears remain fixed in position on their axles and should not require routine service. However, the woodruff (half-moon) keys, set screws, and splines that are normally used to hold gears to their shafts may break or wear and allow the gear to slip or turn freely.

Some gears, such as those used in some starters, slide along their axle shafts. This additional motion can result in additional service procedures. For example, a spring may be used to move the gear along the shaft, and the spring or other actuating mechanism may have to be replaced if it breaks or fails to provide adequate force to shift the gear position.

Advanced principles

Understanding how gears are designed and how they operate can be useful in troubleshooting equipment and in doing performance analysis. Figure 8 on the next page shows contact patterns that may indicate misalignment of gears. Misalignment can also be indicated by the depth of contact, whether the contact between the teeth is high or low.These contact patterns may be apparent in the wear on the gear or may be detected through special tests that involve coating the gear teeth with dyes and paints. Abnormal contact between teeth can lead to poor gear performance and to parts failure.

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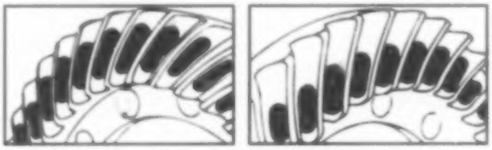
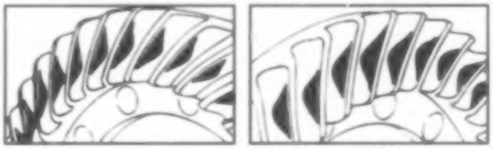
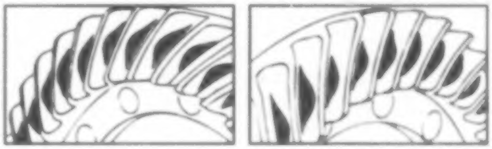
Figure 8: Gear-tooth contact patterns



a. **Ideal tooth contact**



b. **Mating gear too far away**



c. **Mating gear too close**

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Belts Belts are simple in design and relatively inexpensive—making them a popular choice for power product equipment drive trains and equipment drives. There are three common types of belts, as described in the information sheet of this unit. They are the V-belt, flat belt, and cogged belt. V-belts come in smooth and notched designs, which should not be confused with cogged belts.

Belts are routed along pulleys or sheaves or, in the case of cogged belts, gears. All of these devices rotate. They can be drivers or driven, just like gears. The engine-output shaft is connected to a pulley or cogged-belt gear. If there is enough tension on the belt to hold it against the driver pulley, the belt will turn and transfer the rotational force to one or more other pulleys. These pulleys will be mounted to spindles or shafts or axles that will then transfer the force to equipment or drive wheels. A common method for applying or relieving the pressure on a belt is the use of a tensioner pulley, as shown in Figure 9 on the next page.

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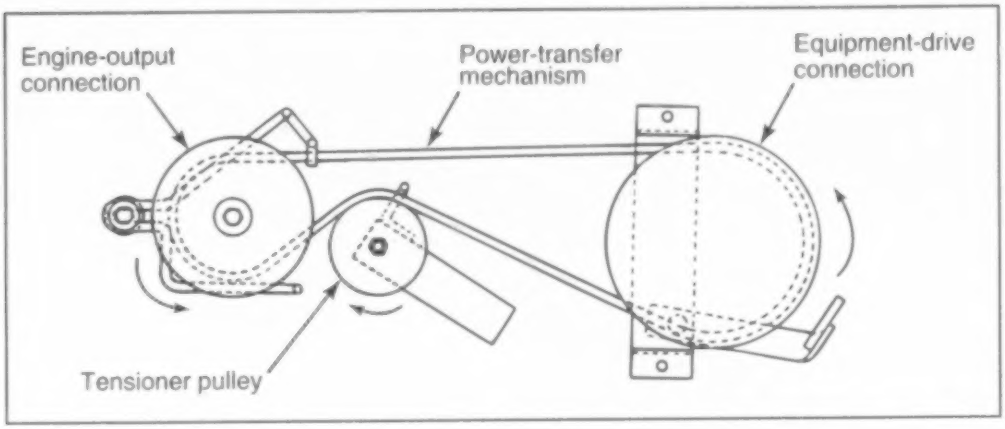
Figure 9: Belt pulley system



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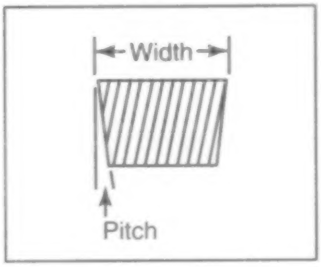
For a system to operate correctly, the belt must be the proper size. There are three critical dimensions on each type of belt. Flat belts must be the proper length, width, and thickness. If they are too long, they will slip or fail to transmit power. If they are too short, there will be too much pressure on the pulleys without the clutch tensioner being engaged. Flat belts that are too wide will lap over the pulleys, while those that are too narrow may slip in the pulleys or be too weak for the forces generated by the equipment. A flat belt that is too thick may be too heavy or inflexible for the system and may rub against belt guides. A belt that is too thin may be too weak or may stretch too quickly.

Cogged belts can experience the same dimensional problems as flat belts. Also, the size of the teeth of the belt must match those of the gears. One concern with cogged belts is that a tooth may break off or wear to a point that it no longer engages the gears. Most cogged belts have teeth only on one side and are flat on the other side, and some are used as flat belts and cogged belts.

V-belts must be the correct length just as the other belts; however, V-belts have more than one width. The top of the V is one width and the bottom of the V is a smaller width. The relationship between the outer width and inner width is determined by the angle or pitch of the sides of the belt (see Figure 10).

Figure 10: V-belt dimensions



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V-belts are generally made of rubber and are often reinforced with wire or fabric. Belts are subject to breaking, cracks, material separation, and fraying (tattering along the edges). Exposure to oil, grease, fuels, and other chemicals can shorten the life of a belt.

V-belts are designed so that the sides of the belt ride on the pulley. The belt should not ride on the bottom of the pulley groove.

Belt service

Belts are not repairable and should be replaced if worn or damaged. While belts do not require periodic maintenance, they do stretch with use, and the belt system may require adjustment, generally by changing the position of the tensioner. Belts that are stretched beyond the range of adjustment should be replaced even if it is in good condition otherwise. Equipment manufacturers normally specify belt tension by stating an amount of deflection. Deflection is how much the belt will move when pressure is applied to it. Often this specification is stated as a distance, such as ⅛ to ¼ inch. This is a rather vague specification for which a technician needs to develop a feel. The specification will usually tell where to apply pressure, but generally does not define the amount of force to apply. Some shops use a belt-deflection gauge—a tool that allows the technician to apply a specific amount of pressure while also measuring the amount of deflection. In most instances, an estimate made by using your hand to deflect the belt is adequate to determine whether the tension is approximately right.

Some equipment manufacturers or belt manufacturers will specify a time interval—such as after each 25 hours of operation—when the belt tension should be checked. In some cases, the specification will give a shorter interval after the installation of a new belt—such as after 5 hours of operation—because a belt will stretch more during its first few hours of operation.

Another important specification for belt operation is the clearance of belt guides. Most equipment manufacturers provide settings for the distance between belts and the shields or pegs that are used to keep belts seated in their pulleys. If these guides are set too closely, the belt will probably rub against them during operation and wear too quickly. If the guides are set too far from the belt, the belt is likely to jump out of the pulley, which could lead to breaking the belt or damaging other components.

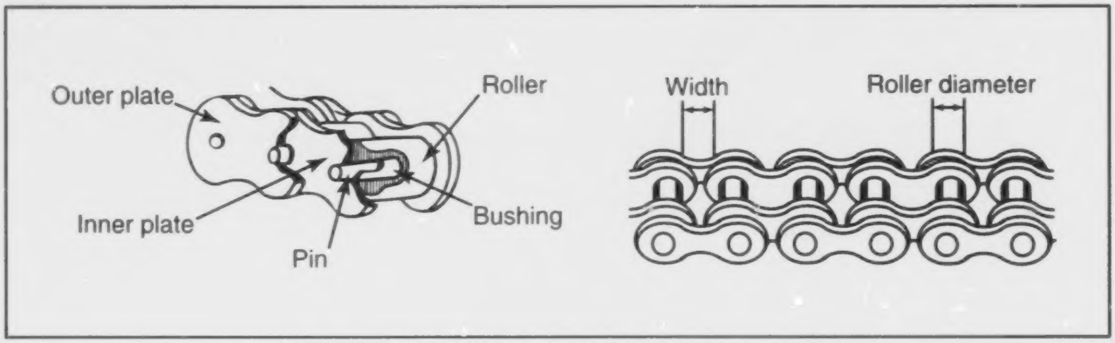
Whenever belts are being serviced, the technician must make sure that the engine is not running and that the belt cannot be engaged if the engine were to start. This is most effectively done by removing the lead from the spark plug and isolating the lead so that it cannot accidentally contact the spark plug. Although it may sound ridiculous, numerous injuries have occurred to technicians who have tried to do belt service or service near belts while the belts were engaged and operating. Similarly, do not remove belt guides and guards. Not only is there a danger of belts breaking or disintegrating but rocks, sticks, and other debris can become caught on belts and be thrown from them.

Chains

Chains are similar to belts in that they transfer rotary motion and are generally engaged or disengaged by changing the tension on them; however, chain systems use sprockets instead of pulleys. Sprockets are wheels with teeth similar to gears. Unlike gears, sprockets usually have a much wider diameter than thickness, and the teeth of the sprocket engage the openings in a chain as the sprocket rotates. Sprockets may be drivers or driven.

The chains used on power product equipment are usually double-roller designs. In this design, the chain consists of two sets of links joined by pins with bushings on the pins as shown in Figure 11. The sprocket teeth fit between consecutive pins, while the bushings help to reduce friction and wear.

Figure 11: Details of chain construction



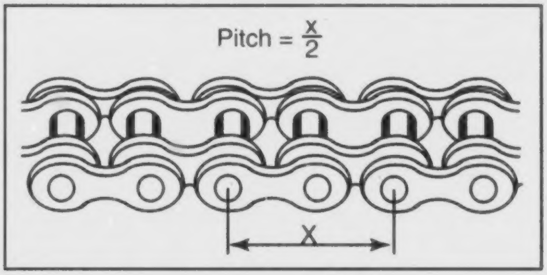
Pitch

Chain systems are designed so that the chain fits over the sprocket teeth and that the teeth engage the chain to a given depth. This fit is determined by the distance between pins. This measurement is called *pitch* and is determined by the following formula:

$$\text{Pitch} = \frac{x}{2}$$

where x is the distance between the corresponding pins on two consecutive links. This distance is illustrated in Figure 12.

Figure 12: Chain pitch



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Length

Pitch is one method of specifying chain. A second method is length. A chain in a specific application will be a given length. While dealers often sell chains made for a specific application, many shops make their own chains by using a chain of the proper pitch and riveting it together in the shop to create a chain of the proper length. This method is not only less expensive and less burdensome than handling pre-made chains of every possible pitch and length, but the capability to assemble chains is useful because, like belts, chains stretch. Often a chain that has stretched can be restored by having a link or two removed. Most manufacturers specify acceptable stretch limits, such as 2 percent or one link or 1 inch. This allows for reducing the chain length by removing links.

Other chain specifications

Chains are also classified by how heavy they are, how many rows of links they have side by side, and other features. To address these design variables, manufacturers have adopted a system of numbering chains. Typical chain numbers are increments of 5, such as 35, 40, 45, 50, etc. The larger the number, the heavier the construction.

Chain service

Little maintenance is required for chains. Tension adjustment is similar to belt-tension adjustment, and many chains are equipped with guides and shields that should be treated in the same way as belt guides and shields.

Chains do require lubrication for most applications; however, the application usually determines the lubrication method. There are two general types of chain installation—open and sealed. An open chain installation has all or portions of the chain exposed or easily accessible by removing a shield. For these configurations, lubrication generally consists of applying a specified lubricant to the length of the chain or specified portions of the chain.

Sealed installations are those in which the chain is completely contained in a case or housing, such as chains in manual transmissions, the tine-drive chains on tillers, etc. In such cases, the lubricant is contained in the housing and should be maintained at a specific level. Often these housings are equipped with fill tubes.

Safety rules for chain service are similar to those for belt service. Again, never perform chain service or service near chains with the engine operating or with the chain engaged for operation.

Mechanical Drive Systems
Unit 2

Student Supplement 2—Bearings and Bushings

Introduction

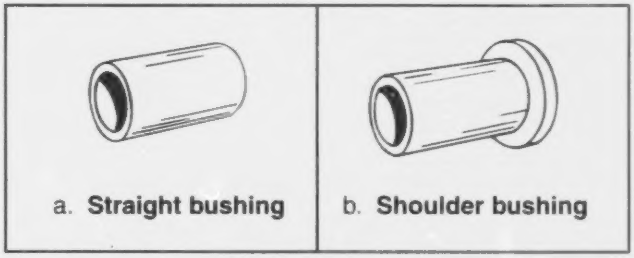
This supplement discusses types of bearings and bushings and their applications in power product equipment. While the material in the information sheet acquaints you with bearings and bushings and their purposes, this supplement provides more details on the design of bushings and bearings. It discusses kinds of bearings commonly used in power product equipment and where bearings and bushings are most often used in such equipment.

In your study of engines, you learned that there are methods for reducing the friction that is created where moving parts come into contact. In addition to lubricants, two of the more common methods of reducing friction and the impact of parts that come into contact are bearings and bushings. You may recall, for example, that most pistons in the engines used to drive power product equipment have journal bearings installed between the connecting rod and crankshaft. Many crankshafts have roller bearings that support one or both ends of the shaft. This supplement will acquaint you with other applications for bearings and for bushings.

Bushings

In general, a bushing is simply a cylinder that fits over another part. For example, most chains used in the drive trains of power product equipment have bushings that serve as the chain rollers. The wheels of many types of power product equipment rest on bushings that fit between the hub of the wheel and the axle. Figure 1 illustrates two of the most common bushing designs—the straight bushing and the shoulder bushing.

Figure 1: Bushings



a. **Straight bushing**

b. **Shoulder bushing**

Bushings serve several purposes. First, bushings reduce friction between moving parts. By installing a bushing between a wheel hub and axle, for example, there is less friction than there would be if the wheel were allowed to ride directly on the axle. In some designs, friction is reduced by allowing the bushing to turn. In all applications, lubricants help to reduce friction. Second, the bearing helps to reduce heat by dissipating it faster than would be the case if the axle and hub were in direct contact. Third, bushings reduce the shock between components by taking up the slack between them. Finally, bushings are disposable. When bushings become worn, they can be thrown away and replaced with relative ease and minimal cost. Continuing with our example, replacing a worn wheel assembly or axle costs considerably more in both labor and materials than replacing a bushing.

Bushing service

In power product equipment, bushings are often made of plastic, and many plastic bushings do not require lubrication. Other bushings are made of metal and may require lubrication with grease, engine oil, or other lubricants. Some bushings require lubrication only when installed or during service that involves disassembly to expose the bushing. Other applications, such as chains and steering columns, may require periodic lubrication. If periodic lubrication is required, the manufacturer will often provide a means of lubricating the bushing, such as a grease fitting.

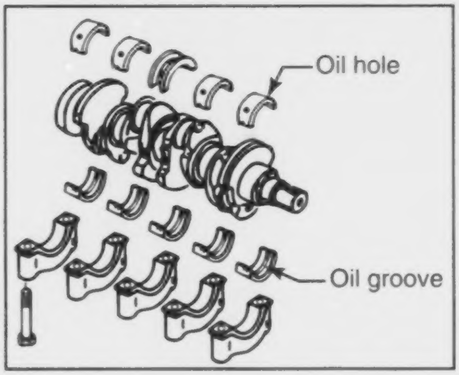
Bearings

Two major kinds of bearings are used in power product equipment: (1) plain bearings and (2) roller-contact bearings.

Plain bearings

A plain bearing is also known as a *friction bearing* or *fluid-film bearing*. This is the type of bearing used in engine piston connecting rods. This application is generally referred to as a *journal bearing* or *sleeve bearing*. The journal is the part of the crankshaft on which the bearing rests, while the bearing forms a sleeve around the journal. In this sense, the bearing functions much like a bushing, but plain bearings are designed to form a film of lubricant between the bearing and the two parts that it separates. The spread of lubricant is accomplished by means of holes or grooves as shown in Figure 2. In some cases, oil is specifically pumped into the hole or groove.

Figure 2: Spread of lubricant in a plain bearing



While the most common use of plain bearings in power product equipment is on crankshaft journals, they are sometimes used with lift systems, equipment drives, and air compressors. When performing service involving plain journals, proper fit and alignment are critical. For example, some plain bearings can be installed with either half on top, but the lubrication hole or groove may be offset and not allow proper lubrication unless a particular half is on top. It is also critical that the recommended lubricant be used. Otherwise, the film layer may be too thin or too thick, the lubricant may not spread properly, or it may not hold up to the temperatures that will be generated.

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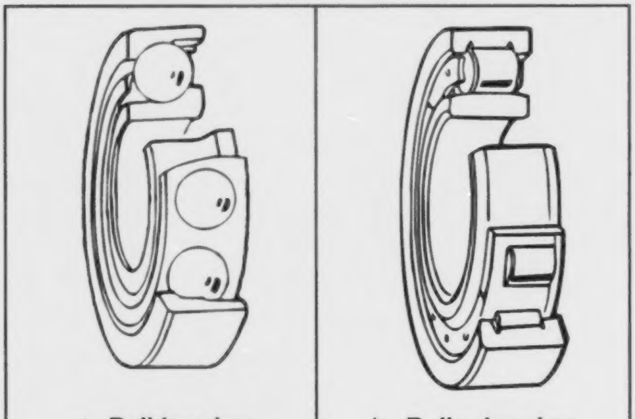
Roller-contact bearings

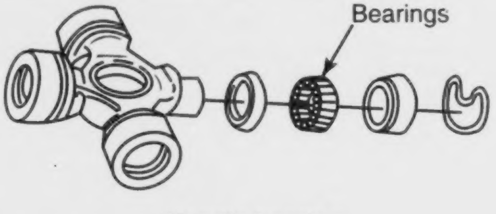
The second common type of bearing—the roller-contact bearing—is known as a *rolling-contact bearing* or *antifriction bearing*. You may have encountered roller-contact bearings in your studies of engines for they are often used with crankshafts and camshafts. The two most common types of roller-contact bearings used with power product equipment are the ball bearing and the roller bearing. In addition to the engine applications just mentioned, roller-contact bearings are used in other places where shafts and axles pass through supports, housings, cases, and other friction contact points. For example, roller-contact bearings are used in the wheel hubs of some heavier equipment and in components such as universal joints.

Ball bearing. Figure 3-a shows a ball bearing. The bearing consists of an inner and an outer cage (race). Metal balls are installed between the inner and outer cage. In this way, the two cages can turn with little friction as the balls roll between them. In most applications, the ball bearing is installed so that the outer cage is stationary and the shaft passes through the center of the bearing, resting on the inner cage. When the shaft turns, the inner cage also turns with a relatively low coefficient of friction. In this way, the bearing functions similarly to a bushing, but is more efficient in reducing friction and heat.

Figure 3: Types of roller-contact bearings



a. **Ball bearing** b. **Roller bearing**



c. **Needle bearing**

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Roller bearings. Two designs of roller bearings are used in power product equipment. One type, which is generally referred to as a *roller bearing*, is constructed like a ball bearing but uses small metal rods in place of metal balls. This design is shown in Figure 3-b on page 53.

The second type of roller bearing is the needle bearing. Needle bearings are also metal rods, but they are much longer in relation to their diameters than are the rollers in roller bearings (see Figure 3-c on page 53). Needle bearings are normally not installed in cages. They are usually installed in cups, as in U-joint applications, or in shells similar to bushings for use on axles and other shafts that pass through the bearing. The bearings are held in place by grease and their precision fit until installed and then by pressure from the shaft.

Sealed/non-sealed bearings

Another feature used to classify bearings is whether a bearing is sealed or non-sealed. Sealed bearings are designed so that they do not require periodic lubrication.

Bearing service

Bearings are not normally repairable. If they show signs of excessive wear or damage, they should be replaced. Even if a single needle breaks in a needle bearing, it is better to replace the entire bearing than to try to replace just one needle. However, when inspecting bearings for damage, a number of clues are available as to the operating conditions of the system. For example, discoloration of the races may indicate overheating or excessive pressure. Pitting of the contact surfaces may indicate the presence of contaminants such as dirt and sand or may be a sign that another part may be deteriorating and shedding metal particles. Uneven wear may indicate improper alignment or a bent shaft. A technician should look for such clues whenever inspecting bearings.

Certain types of bearings also require other service than that mentioned in the previous paragraph. Non-sealed bearings require periodic lubrication. Journal bearings are typically lubricated during use and require no additional service after installation other than to ensure that the bearing is receiving adequate lubrication during any service that exposes the bearing for inspection.

Roller-contact bearings generally require periodic lubrication per the equipment manufacturer's maintenance schedule. Roller bearings and ball bearings used for engine shafts and other applications that are relatively well protected usually have rather long maintenance intervals. Those used for wheel bearings have moderately long service intervals, although for equipment that is exposed to water and harsh conditions—such as ATV wheel bearings—the intervals are likely to be shorter.

Student Supplement 2

Ball bearings and roller bearings are normally lubricated upon installation and then periodically removed and relubricated. There are two common methods for lubricating caged bearings. They can be hand-packed—a process in which grease is forced into the cages and around the bearings by hand. This is perhaps the most common method for power product equipment roller-contact bearings. The second process is to use a bearing packer, which is a machine that forces grease into the bearing. Bearing packers are perhaps capable of doing a more thorough job of packing large, complicated bearing cages but are not generally required for power product equipment bearings.

During periodic service, caged bearings are removed from their installations and thoroughly cleaned with a mild solvent. Cleaning removes the old grease and contaminants and allows a better inspection. If the bearing is in good shape, it can be packed as at initial installation and reinstalled, although some technicians make a practice of replacing any bearing that is difficult to remove. The primary concerns are to use a recommended lubricant and to ensure that the bearings and cages are adequately filled with grease and to be sure that the bearings are properly installed.

Needle bearings usually have grease packed around them and can be installed without additional packing. Periodic service should be in accordance with the manufacturer's recommendations. Some needle-bearing applications, like some bushing applications, provide lubrication access points, such as lubrication fittings. The technician uses a hand or power pump to deliver grease to the bearings through the fitting.

These guidelines and the manufacturers' service manuals should be helpful in determining the types of bearings and bushings and required service for the equipment that you will work on during your career. Study the equipment in your facility and see how many types of bearings and bushings you can identify and the service procedures associated with each.

Mechanical Drive Systems
Unit 2

Assignment Sheet 1—Determine Mechanical Drive-Train Service Specifications and Parts Requirements

Name ______________________________ Date ______________

Evaluation criteria **Rating**

Directions have been followed. ______

Minimum of 85 percent of answers are correct. ______

Overall rating ______

Evaluator's comments ______________________________

____

____

Introduction

As with other power product equipment systems, the parts of the mechanical drive train must fit together properly and must be correctly adjusted in order to operate as designed. Parts selection and adjustments are documented in service manuals, catalogs, computer data bases, on-line services, and other resources. To correctly service a mechanical drive train, the technician must know how to locate and apply the information that pertains to the equipment being serviced. In this assignment sheet, you will practice selecting parts and determining specifications for equipment that you are likely to service in your career as a power product equipment technician.

Exercise

Directions

Using the resources available in your facility, determine the part numbers and specifications requested in the following questions. Write your answers on the blank lines provided with each question, or follow the specific directions with the question.

Assignment Sheet 1

1. The illustration in Figure 1 on the next page shows a Peerless MST transaxle.

   a. What type of gasket material is used with this transaxle?

   Gasket material — ______________________

   b. The part labeled 15 is the ring gear. What is the part number for the ring gear?

   Part number — ______________________

   c. What type and weight of gear oil should be used in this transaxle?

   Type and weight — ______________________

   d. Approximately how many pints of gear oil are required?

   Number of pints — ______________________

   e. What torque should be used for installing the cap screws that hold the transaxle case and cover together?

   Torque — ______________________

2. The International Harvester Cub Cadet Model 60 riding lawn mower uses a chain drive.

   a. What is the recommended amount of slack and location of that slack for the drive chain?

   Amount of slack and location — ______________________

   ____

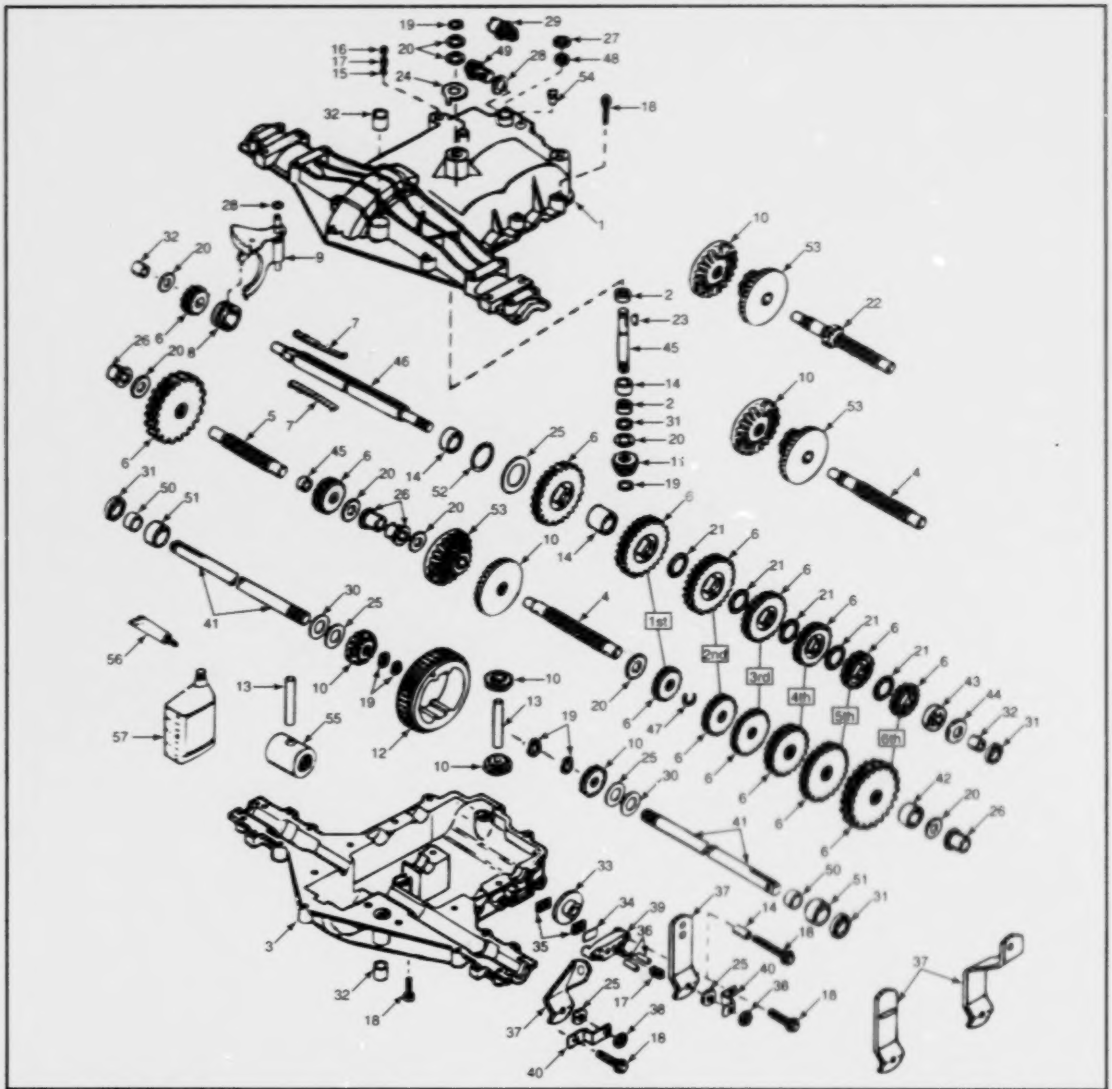
   ____

   b. What is the recommended chain lubricant?

   Chain lubricant — ______________________

Assignment Sheet 1

Figure 1: Peerless MST transaxle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1.	Transaxle cover	16.	Set screw	31.	Oil seal	46.	Shifter & brake shaft
2.	Needle bearing	17.	Spring	32.	Bushing	47.	Retaining ring
3.	Transaxle case	18.	Screw	33.	Brake disk	48.	Square cut ring
4.	Countershaft	19.	Retaining ring	34.	Brake pad plate	49.	Threaded plug
5.	Output shaft	20.	Thrust washer	35.	Brake pad	50.	Needle bearing
6.	Spur gear	21.	Cup washer	36.	Dowel pin	51.	Sleeve
7.	Shift key	22.	Countershaft & gear	37.	Brake lever	52.	Inverted retaining ring
8.	Shift collar	23.	Woodruff key	38.	Locknut	53.	Bevel & spur gear
9.	Shift rod & fork	24.	Anti-rotation washer	39.	Brake pad holder	54.	Oil fill plug
10.	Bevel gear	25.	Flat washer	40.	Brake lever bracket	55.	Axle coupling
11.	Input bevel pinion	26.	Flanged bushing	41.	Axle	56.	Liquid gasket RTV silicone
12.	Ring gear	27.	Pushnut	42.	Countershaft spacer	57.	Gear oil
13.	Drive pin	28.	"O"-ring	43.	Brake shaft spacer		
14.	Spacer	29.	Neutral start switch	44.	Flat washer		
15.	Ball	30.	Washer	45.	Input shaft		

Reproduced by permission of the Peerless Division of Tecumseh Products Company, Grafton, Wisconsin.

Assignment Sheet 1

3. Figure 2 on the next page illustrates the transmission drive belt for certain International Harvester riding lawn mowers, such as Models 55, 75, and 85.

   a. What is the clearance required at each belt guide indicated below?

      Clearance at belt guide 1 — ______________________

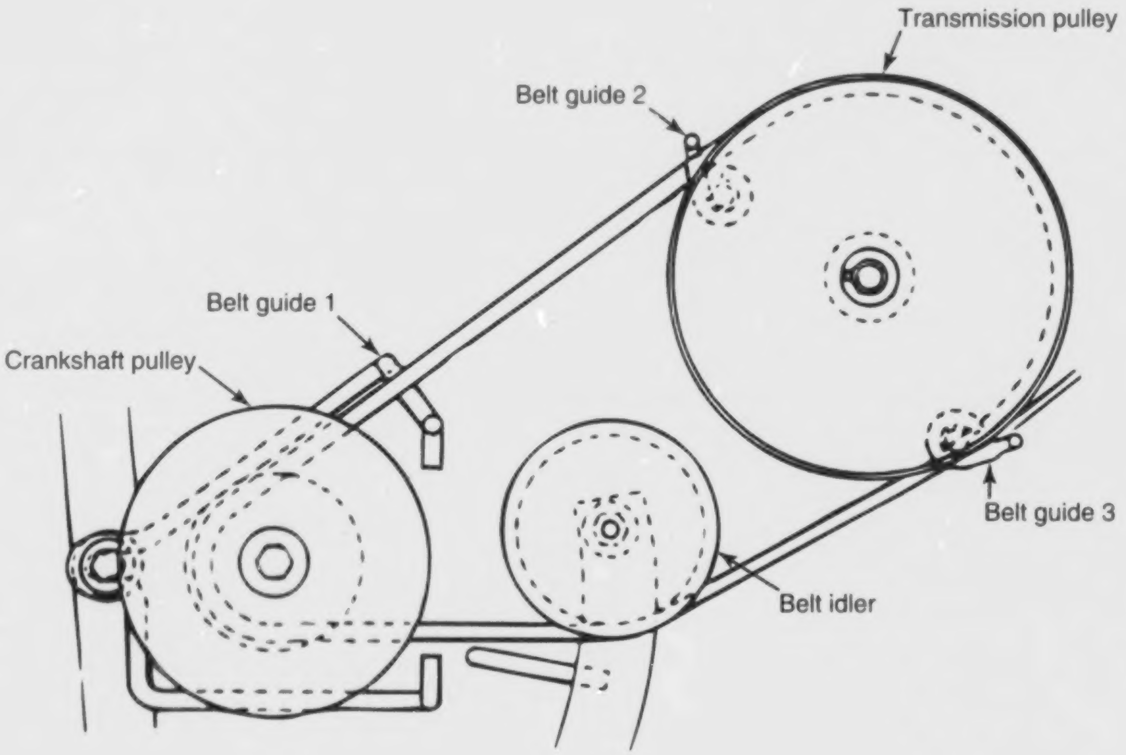
      Clearance at belt guide 2 — ______________________

      Clearance at belt guide 3 — ______________________

   b. Are the adjustments done with the clutch engaged or disengaged? (Circle the correct answer below.)

      Engaged Disengaged

Figure 2: International Harvester transmission drive belt


Transmission pulley
Belt guide 2
Belt guide 1
Crankshaft pulley
Belt guide 3
Belt idler

Reproduced by permission of Mike Barnett, MTD Products, Cub Cadet Corp., Cleveland, Ohio.

Assignment Sheet 1

4. Ariens uses a friction drive on many of their riding lawn mowers. The transmission speed is determined by the relationship of the friction wheel to the drive disc.

   a. Is the speed lower or higher as the position of the friction wheel moves toward the edge of the drive disc? (Circle the correct answer below.)

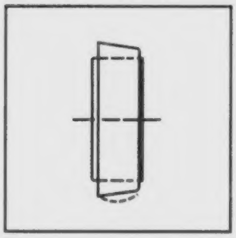
      Lower   Higher

   b. Is the drive train in neutral when the friction wheel is at the center or at the edge of the drive disc? (Circle the correct answer below.)

      Center   Edge

   c. Normal wear and operation of the friction wheel lead to a slight, even reduction in diameter and small cracks that parallel the circumference of the wheel. What problems are likely to result in the friction wheel being worn at an angle with a smaller diameter on one edge than the other as shown in Figure 3?

Figure 3



Resulting problems — ______________________________

____

____

Mechanical Drive Systems
Unit 2

Assignment Sheet 2—Determine Mechanical Equipment-Drive Service Specifications and Parts Requirements

Name ______________________________ Date ________________

Evaluation criteria	**Rating**
Directions have been followed.	______
Minimum of 85 percent of answers are correct.	______
Overall rating	______

Evaluator's comments ____

____

____

Introduction Most of your studies to this point have dealt with the engine and those power product equipment systems used to support engine operation, such as starting and lubrication systems. Such engines are the common factor among power product equipment and the force that makes the equipment work. However, there are other systems that are essential to accomplishing the work required of power product equipment. These are the systems that transmit the power of the engine, control it, and direct it in such a way that useful work can be done. In this unit, you learned that the two primary types of power application in power product equipment are drive trains and equipment drives. This assignment sheet will help to expand your study of mechanical equipment drives.

Exercise

Directions Using the resources available in your facility, determine the part numbers and specifications requested in the following questions. Write your answers on the blank lines provided with each question.

Assignment Sheet 2

1. The illustration in Figure 1 on the next page shows the belt configuration for the drive belt and PTO used on Deutz-Allis Models Scamp 5 and 405 and Simplicity Models such as 305, 315, 355, and 3005.

    a. What number in the illustration is used to label the main drive (engine) pulley?

    Illustration number — ______________________

    b. What number in the illustration is used to label the transmission input pulley?

    Illustration number — ______________________

    c. What number in the illustration is used to label the PTO clutch idler pulley?

    Illustration number — ______________________

    d. What size belt is used for the PTO drive?

    Belt size — ______________________

    e. What size belt is used for the main drive belt?

    Belt size — ______________________

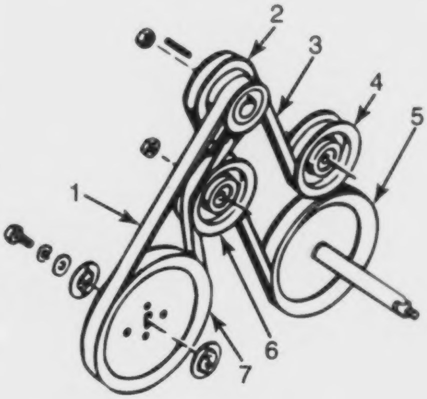
2. The illustration in Figure 2 on the next page shows the inside of the chain casing for MTD Models 310 and 700 garden tillers. Two chains are used to provide a gear reduction so that the maximum speed of the tiller blades is 135 rpm. What size of chain is used for the two chains in this installation?

    a. Chain 1 — ______________________

    b. Chain 2 — ______________________

Assignment Sheet 2

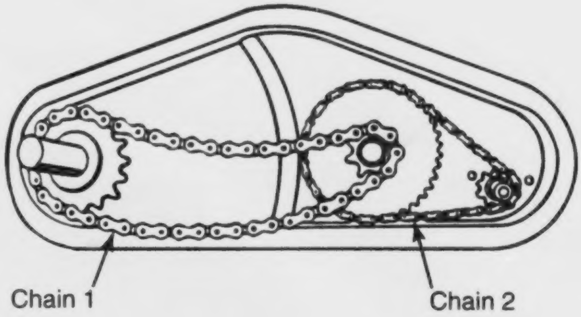
Figure 1: Belt configuration



1. Traction drive belt idler
2. Engine pulley
3. PTO drive belt
4. PTO clutch idler pulley
5. Pulley and jackshaft
6. Traction drive clutch idler pulley
7. Transmission input pulley

Reproduced by permission of Simplicity Manufacturing, Inc., Port Washington, Wisconsin.

Figure 2: Chain casing



Reproduced by permission of Mike Barnett, MTD Products, Inc., Cleveland, Ohio.

Assignment Sheet 2

3. Figure 3 on the next page shows the PTO drive for Deutz-Allis garden tractors, such as Models 1914 and 1916. The questions below refer to this system.

   a. What kind of clutch is used with this PTO?

      Clutch system — ______________________________

   b. What is the maximum end play allowed for the shaft?

      Maximum end play — ______________________________

   c. What should the clearance between the clutch armature and rotor be when the clutch is properly adjusted?

      Clearance — ______________________________

      ____

4. MTD offers a series of chipper shredders, including Models 645B and 648B. The chipper shredder has an impeller blade and flail blade mounted directly to the engine shaft. The following questions apply to that unit.

   a. The impeller assembly is available in a keyed and a tapered design. What is the part number for each type?

      Part number for keyed design — ____________________

      Part number for tapered design — ____________________

   b. Chipper blades are available in steel and in chrome. What are the part numbers for each type?

      Part number for steel blade — ____________________

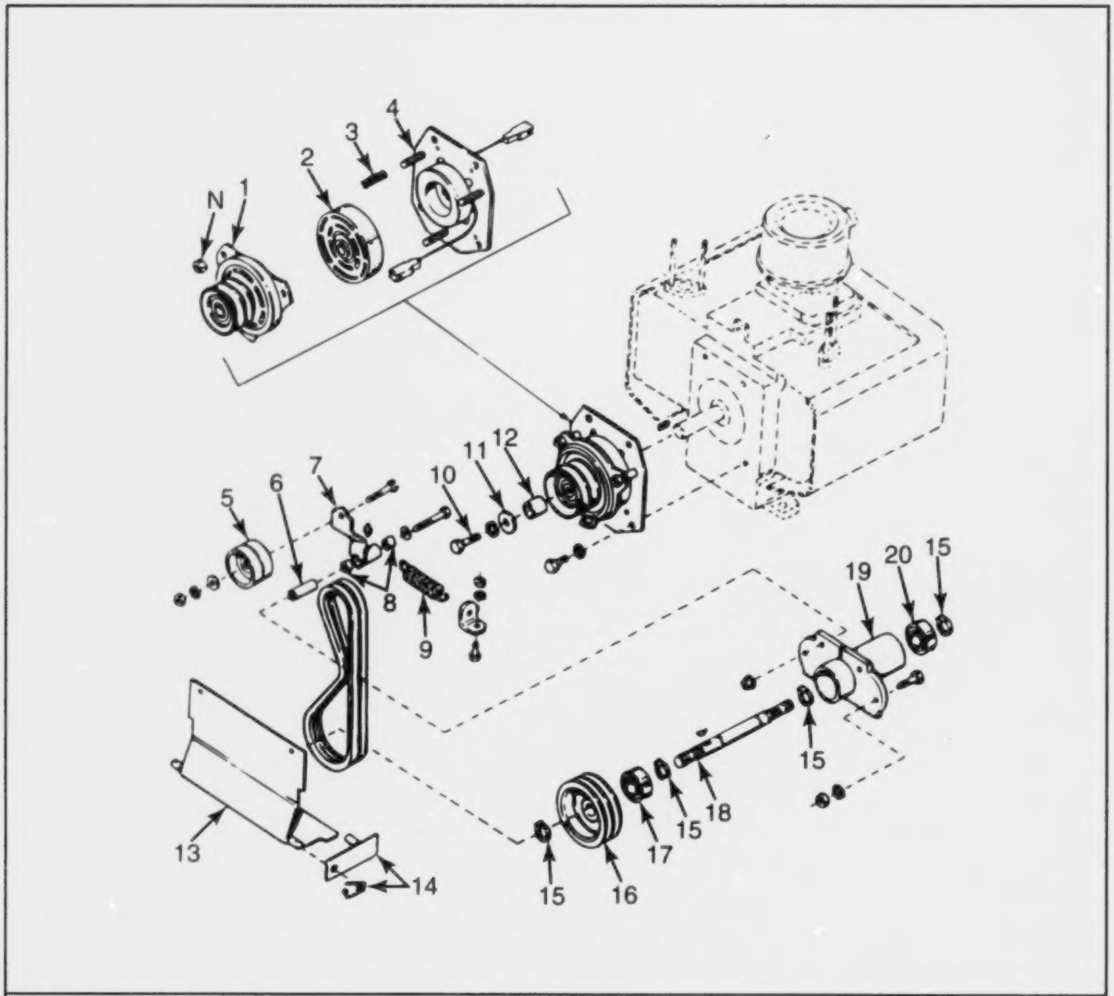
      Part number for chrome blade — ____________________

   c. What is the torque value for the shredder blade?

      Torque value — ______________________________

Assignment Sheet 2

Figure 3: Deutz-Allis garden-tractor PTO drive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1. Armature
2. Rotor
3. Springs
4. Field
5. Pulley
6. Spacer
7. Idler arm
8. Bushings
9. Spring
10. Cap screw
11. Washer
12. Spacer
13. PTO guard
14. Clip pin and link
15. Snap ring
16. PTO drive pulley
17. Bearing
18. PTO shaft
19. Bearing support
20. Bearing

Reproduced by permission of Simplicity Manufacturing, Inc., Port Washington, Wisconsin.

Mechanical Drive Systems
Unit 2

Assignment Sheet 3—Determine Mechanical Clutch-System Service Specifications and Parts Requirements

Name ______________________________ Date ______________

Evaluation criteria **Rating**

Directions have been followed. _______

Minimum of 85 percent of answers are correct. _______

Overall rating _______

Evaluator's comments ______________________________

____

____

Introduction Clutches provide equipment operators with a means for controlling the application of engine power to drive trains and equipment drives. For this function to be performed properly, there must be correct alignment and spacing among clutch components and between clutch components and the devices with which they mate, such as engine output shafts and equipment drives. As a result, it is vital that the correct parts be used and that they be properly aligned and adjusted. In this assignment sheet, you will practice selecting parts and determining specifications for equipment that you are likely to service in your career as a power product equipment technician.

Exercise

Directions Using the resources available in your facility, determine the part numbers and specifications requested in the following questions. Write your answers on the blank lines provided with each question, or follow the specific directions with the question.

Assignment Sheet 3

1. The illustration in Figure 1 on the next page shows a traction-drive clutch used on MTD models such as 380, 385, 390, 395, 470, 475, 480, and 485. What is the difference between the pulleys labeled 6 and 7? Give part numbers for the two pulleys or describe the difference.

   ____

   ____

   ____

2. The clutch assembly illustrated in Figure 2 on the next page is used on Poulan chain-saw Models 5500 and 6000.

   a. Many chain saws use left-hand threaded retaining hardware for their clutch assemblies. Is that true of the assembly illustrated? (Circle the correct answer below.)

      Yes No

   b. What torque should be used when tightening the clutch nut (Part 21)?

      Torque — ____________________________

   c. Two springs are shown as Part 15. If one of the springs is worn, what should be done? (Circle the correct answer below.)

      Replace only the defective spring.

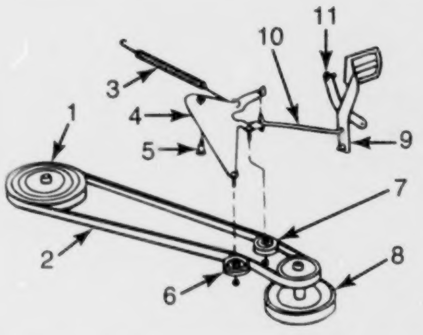
      Replace the springs as a set.

      Replace the springs with the next smaller size.

      Replace the springs with the next larger size.

Assignment Sheet 3

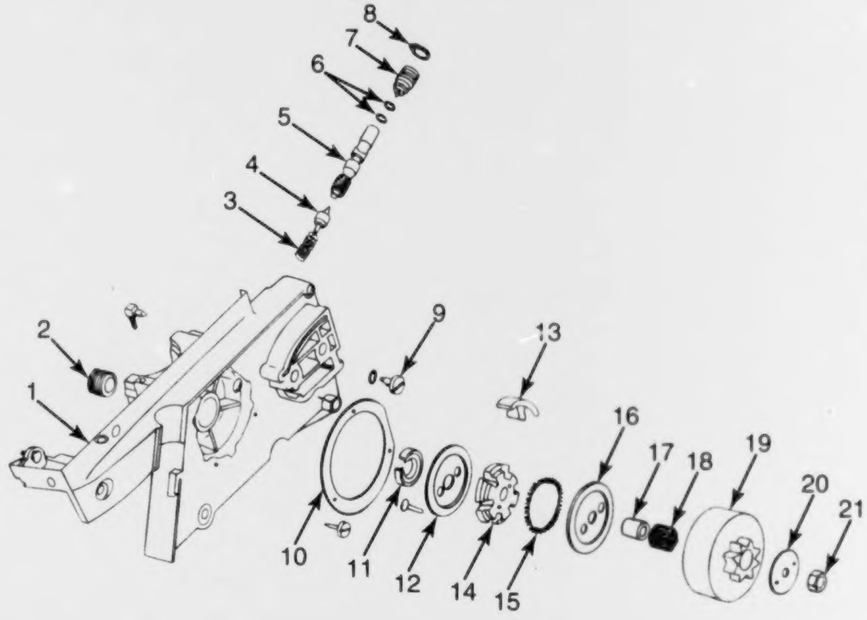
Figure 1: MTD traction-drive clutch



1. Transmission input pulley
2. Traction drive belt
3. Clutch spring
4. Idler bracket
5. Pivot bolt
6. Flat idler
7. Vee idler
8. Engine pulley
9. Clutch pedal
10. Clutch rod
11. Clutch lock

Reproduced by permission of Mike Barnett, MTD Products, Inc., Cleveland, Ohio.

Figure 2: Poulan chain-saw clutch assembly



1. Right crankcase half
2. Oil-pump worm gear
3. Spring
4. Thrust pin
5. Oil-pump plunger
6. O-rings
7. Adjusting screw
8. Snap ring
9. Cam screw
10. Cover plate
11. Seal
12. Guide plate
13. Clutch shoe
14. Clutch hub
15. Garter spring
16. Guide plate
17. Inner bearing race
18. Needle bearing
19. Clutch drum
20. Washer
21. Nut

Reproduced by permission of Poulan, Shreveport, Louisiana.

Assignment Sheet 3

3. The illustration in Figure 3 on the next page shows a multi-disc clutch system as used on many models of Kawasaki motorcycles.

   a. What torque value should be used when tightening the bolt labeled as item 18 in the illustration?

      Torque — ____________________

   b. What is the minimum side clearance of the clutch?

      Side clearance — ____________________

   c. What treatment is required for the surface of plates if new, dry steel or friction plates are installed?

      Treatment — ____________________

   d. Do the parts identified as 2 and 16 in the illustration mate with each other? (Circle the correct answer below.)

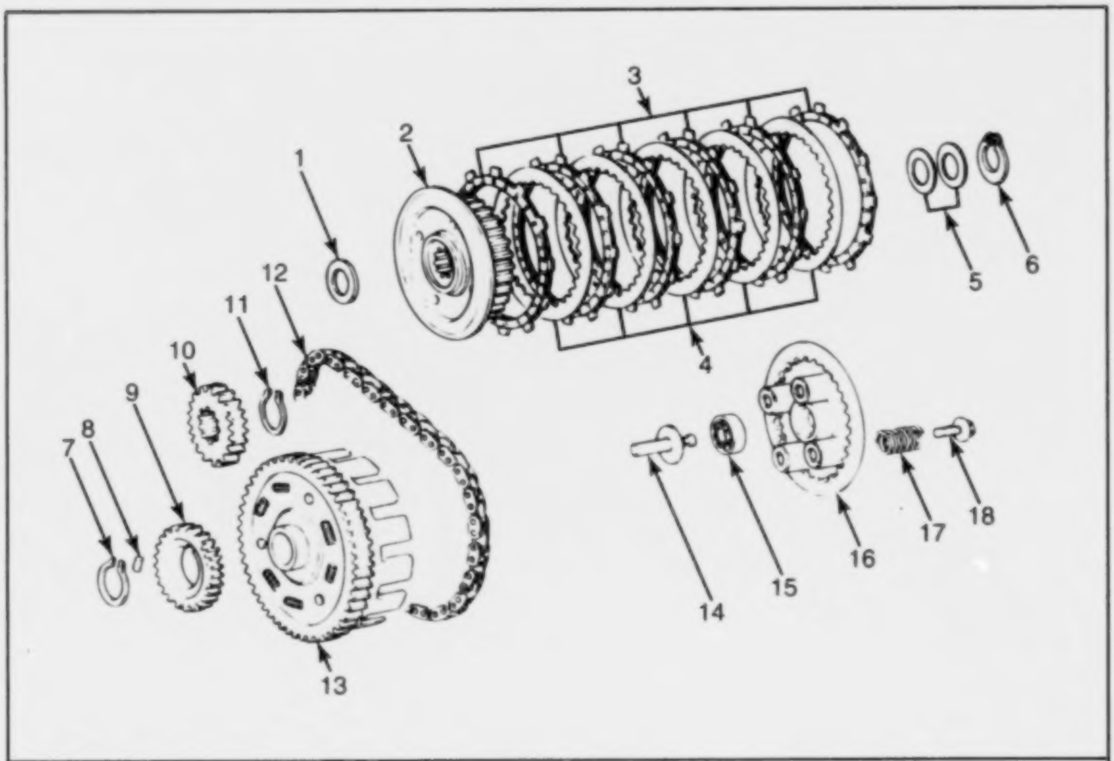
      Yes No

   e. What torque value should be used to tighten the engine pulley nut?

      Torque — ____________________

Assignment Sheet 3

Figure 3: Multi-disc clutch system



1. Thrust washer
2. Clutch hub
3. Friction plates
4. Steel plates
5. Shim(s)
6. Circlip
7. Circlip
8. Pin
9. Oil-pump drive gear
10. Primary sprocket
11. Circlip
12. Primary chain
13. Clutch housing
14. Spring-plate pusher
15. Ball bearing
16. Spring plate
17. Spring
18. Bolt

Reproduced by permission of Kawasaki Motors Corporation, U.S.A., Irvine, California.

Assignment Sheet 3

4. MTD uses a right-angle power take-off on some of its garden tractors, as illustrated in Figure 4 below. The clutch system uses a pressure plate.

   a. What type of linkage is provided between the clutch and the actuator?

   Linkage — ______________________________

   b. How are the inner and outer discs attached to the PTO shaft?

   ____

   c. What is the recommended clearance between the clutch arm (Item 9) and the bearing cover?

   Recommended clearance — ______________________________

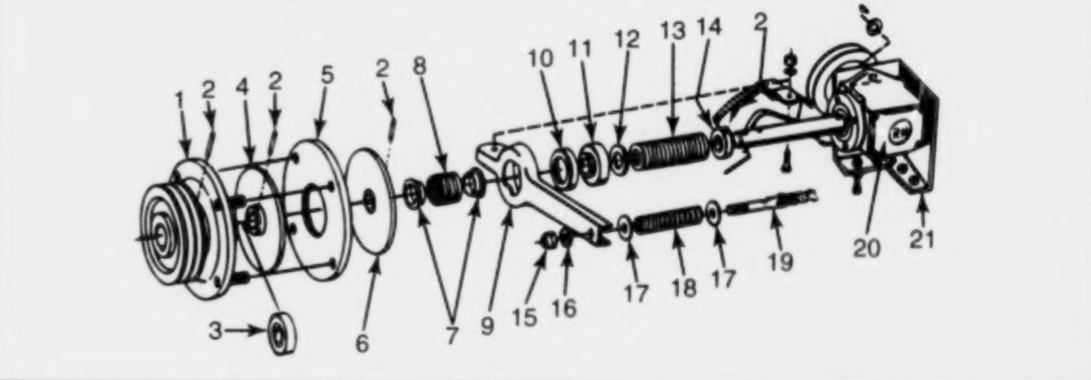
   d. What is the recommended belt deflection if 10 pounds (44.5 N) of force are applied midway between the transmission input pulley and the right-angle drive pulley?

   Recommended deflection — ______________________________

   e. What item number in the illustration is used to adjust the clutch?

   Item number — ______________________________

Figure 4: Right-angle PTO



1. PTO drive and adapter
2. Roll pins
3. Bearing
4. Outer disc
5. Pressure plate
6. Inner disc
7. Spring guide
8. Spring
9. Clutch arm
10. Bearing cover
11. Bearing
12. Washer
13. Spring
14. Collar
15. Adjusting nut
16. Washer
17. Washer
18. Spring
19. Rod and chain
20. Right-angle drive unit
21. Bracket

Reproduced by permission of Mike Barnett, MTD Products, Inc., Cleveland, Ohio.

Mechanical Drive Systems
Unit 2

Job Sheet 1—Perform Routine Maintenance on Mechanical Drive Trains

Introduction

This job sheet covers the routine maintenance associated with mechanical drive trains. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect mechanical drive-train components
- Lubricate gears, chains, and U-joints
- Adjust belt tension
- Align pulleys and shafts

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of performing routine maintenance on mechanical drive trains and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one mechanical drive train. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a mechanical drive train.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 1

Worksheet—Perform Routine Maintenance on Mechanical Drive Trains

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 1

Worksheet—Perform Routine Maintenance on Mechanical Drive Trains

---

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Mechanical Drive Systems
Unit 2

Job Sheet 2—Repair Mechanical Drive Trains

Introduction

This job sheet covers the repair procedure associated with mechanical drive trains. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace mechanical drive-train components, including gears, belts, U-joints, etc.
- Overhaul mechanical drive-train subsystems, including gearboxes and pulley systems
- Perform adjustments to return equipment to original specifications

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of repairing a mechanical drive train and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one mechanical drive train. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a mechanical drive train.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 2

Worksheet—Repair Mechanical Drive Trains

Name ______________________ Attempt number ________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 2

Worksheet—Repair Mechanical Drive Trains

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Mechanical Drive Systems
Unit 2

Job Sheet 3—Perform Routine Maintenance on Mechanical Equipment Drives

Introduction

This job sheet covers the routine maintenance associated with mechanical equipment drives. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect equipment-drive components
- Lubricate gears, chains, and U-joints
- Adjust belt tension
- Align pulleys and shafts

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 2.

2. Watch your instructor's demonstration of performing routine maintenance on mechanical equipment drives and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one mechanical equipment drive. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a mechanical equipment drive.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/ materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 3

Worksheet—Perform Routine Maintenance on Mechanical Equipment Drives

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 3

Worksheet—Perform Routine Maintenance on Mechanical Equipment Drives

---

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Mechanical Drive Systems
Unit 2

Job Sheet 4—Repair Mechanical Equipment Drives

Introduction

This job sheet covers the repair procedure associated with mechanical equipment drives. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace mechanical equipment-drive components, including gears, belts, U-joints, etc.
- Overhaul mechanical equipment-drive subsystems, including gearboxes and pulley systems
- Perform adjustments to return equipment to original specifications

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 2.

2. Watch your instructor's demonstration of repairing mechanical equipment drives and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one mechanical equipment drive. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a mechanical equipment drive.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 4

Worksheet—Repair Mechanical Equipment Drives

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 4

Worksheet—Repair Mechanical Equipment Drives

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Mechanical Drive Systems
Unit 2

Job Sheet 5—Perform Routine Maintenance on Mechanical Clutch Systems

Introduction

This job sheet covers the routine maintenance associated with mechanical clutch systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect mechanical components
- Lubricate gears, bearings, and bushings
- Adjust belt tension
- Adjust component alignment and spacing

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 3.

2. Watch your instructor's demonstration of performing routine maintenance on mechanical clutch systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one mechanical clutch system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a mechanical clutch system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 5

Worksheet—Perform Routine Maintenance on Mechanical Clutch Systems

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ____

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 5

Worksheet—Perform Routine Maintenance on Mechanical Clutch Systems

---

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Mechanical Drive Systems
Unit 2

Job Sheet 6—Repair Mechanical Clutch Systems

Introduction

This job sheet covers the repair procedure associated with mechanical clutch systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace mechanical clutch components, including gears, belts, friction surfaces, drums, springs, etc.
- Overhaul mechanical clutch subsystems, including actuators, linkages, etc.
- Perform adjustments to return equipment to original specifications.

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 3.

2. Watch your instructor's demonstration of repairing mechanical clutch systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one mechanical clutch system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a mechanical clutch system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 6

Worksheet—Repair Mechanical Clutch Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 6

Worksheet—Repair Mechanical Clutch Systems

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Principles of Fluid Power
Unit 3

Objective Sheet

Unit objective

After completing this unit, the student should be able to describe the principles of fluid power that apply to power product equipment and perform typical service procedures required for fluid-power systems. The student should demonstrate these competencies by completing the assignment sheet and job sheets and by scoring a minimum of 85 percent on the written test.

Specific objectives

After completing this unit, the student should be able to

1. Complete statements concerning the basic concepts of physics related to fluid-power transmission.
2. Match types of fluid-power systems commonly used in power product equipment to their correct descriptions.
3. State the functions of the major components of hydraulic systems.
4. Identify common symbols used on hydraulic diagrams.
5. Match types of hydraulic fluids used in power product equipment to their correct descriptions.
6. State safety rules for working with hydraulic systems.
7. State guidelines for preventing equipment damage when working with hydraulic systems.
8. List types of power product equipment that use hydraulic power.
9. List applications of hydraulic systems in power product equipment.
10. Identify types of hydraulic pumps.
11. State functions of the major components of hydraulic pumps.
12. Complete statements about the principles of operation of centrifugal hydraulic pumps.
13. Complete statements about the principles of operation of rotary hydraulic pumps.
14. Complete statements about the principles of operation of diaphragm hydraulic pumps.
15. Complete statements about the principles of operation of piston hydraulic pumps.
16. List typical service procedures required for hydraulic systems.
17. List specialty tools used to perform hydraulic-system service.
18. State the functions of the major components of pneumatic systems.

Objective Sheet

19. Identify common symbols used on pneumatic diagrams.
20. State safety rules for working with pneumatic systems.
21. State guidelines for preventing equipment damage when working with pneumatic systems.
22. List types of power product equipment that use pneumatic power.
23. List applications of pneumatic systems in power product equipment.
24. Identify types of pneumatic pumps.
25. State functions of the major components of pneumatic pumps.
26. Complete statements about the principles of operation of centrifugal pneumatic pumps.
27. Complete statements about the principles of operation of propeller pneumatic pumps.
28. Complete statements about the principles of operation of diaphragm pneumatic pumps.
29. Complete statements about the principles of operation of reciprocating pneumatic pumps.
30. List typical service procedures required for pneumatic systems.
31. List specialty tools used to perform pneumatic-system service.
32. Interpret flow diagrams and assembly drawings. (Assignment Sheet 1)
33. Measure hydraulic-system temperature. (Job Sheet 1)
34. Measure hydraulic-system pressure. (Job Sheet 2)
35. Measure hydraulic-system flow. (Job Sheet 3)
36. Measure air pressure. (Job Sheet 4)
37. Measure airflow. (Job Sheet 5)

Principles of Fluid Power
Unit 3

Information Sheet

1. **Statements concerning the basic concepts of physics related to fluid-power transmission**

Note: In Unit 1, "Principles of Power Transmission," you studied several principles of physics that apply to power transmission in power product equipment, and that unit also provided you with general definitions of the types of power-transmission systems: mechanical, hydraulic, pneumatic, electrical, and magnetic. This unit will provide you with more information on how hydraulic and pneumatic systems are used to transmit power—a field of study that is referred to as *fluid power*.

- **A fluid is a substance that can flow at the molecular level; there are two types of true fluids—gases and liquids.**

- **Fluid power is the use of a fluid to transmit power.**

  Note: Just as the mechanical linkages you studied in Unit 2 are used to transmit power, both gases and liquids are also used to transmit power in power product equipment.

- **Gas in a container compresses when pressure is applied to the gas, and the compressed gas exerts a force on its container in all directions equal to the pressure that has been applied.**

  Note: Both gases and liquids assume the shape of their container; additionally, a gas will expand to distribute itself evenly throughout its container. Pressure is applied to a gas in a container in one of two ways: (1) by decreasing the volume of the container or (2) by increasing the amount of gas in the container without changing the volume of the container. For example, if you place a balloon filled with air in a can and press down on the balloon, the air in the balloon will compress (the balloon will take up less space in the can).

- **A liquid in a container does not compress when pressure is applied to the liquid; pressure applied to a liquid is transmitted throughout the liquid.**

  Note: Because a liquid in a confined space will not compress, it acts like a solid object. For example, if you place a water-filled balloon in a horizontally laid can with open ends, you can move a wooden block placed at one end of the can by pushing on the balloon from the other end of the can.

- **Fluids flow from areas of high pressure to areas of lower pressure.**

  Note: You have demonstrated this principle if you have ever filled a balloon with air and then released the balloon to fly around in the room. The air in the balloon is at a higher pressure than the air in the room, and the air inside the balloon will discharge (flow) from the balloon until the air pressure inside the balloon and in the room are the same.

- **A fluid in motion creates an area of lower pressure; the pressure differential increases as the flow rate of the fluid increases.**

  Note: The venturi portion of a carburetor is an example of this principle: air passing through a narrow portion of the throttle body creates a low-pressure area, causing gasoline to flow from the fuel bowl to mix with air.

- **If a fluid under pressure is forced through an area of smaller volume, the flow rate of the fluid increases.**

  Note: The principle presented in the above statement is called *Bernoulli's Law.* You have seen an example of this law each time you have closed off part of the end of a garden hose to make the water stream out faster.

- **By controlling the amount of pressure in a system and the system's response to the pressure, you can multiply or reduce the amount of force transmitted in the system and increase or decrease the system's rate of output.**

  Note: The purpose of a power-transmission system is to control the transmission of force. To accomplish this goal, fluid systems consist of (1) a means of applying pressure to the fluid, (2) a means of directing the force to the required application, and (3) a means of outputting the required amount of force. Pumps, fans, compressors, lines and hoses, turbines, hydraulic motors, valves, and other devices are used as the means to accomplish this goal in fluid-power systems.

2. Types of fluid-power systems commonly used in power product equipment and their descriptions

Note: The following applications of fluid power are common in power product equipment. Generally, the internal-combustion engine is the original power source for the equipment. Fluid power may then be used to transmit force through the equipment, as in the case of a hydraulic transmission or hydraulic equipment drive. In some cases, fluid power is the final output of the equipment. For example, an air compressor's job is to compress air. A water pump's job is to pump water. In both of these instances, the creation of the fluid power is the purpose of the power product equipment. Furthermore, a piece of power product equipment may exhibit more than one application of fluid power. For example, a paint sprayer may operate by creating an airstream that is used to draw liquid paint from a reservoir so that the paint can be mixed with the air and applied as a spray.

- **Compressed-air system**—System that uses air stored at a pressure greater than the pressure of the surrounding atmospheric air

  Examples: Air compressors, pneumatic tools, pneumatic lift systems

  Note: At sea level, atmospheric pressure is approximately 14.7 pounds per square inch. Basically, this amount is the weight of a column of air with a 1-square-inch base extending the height of the atmosphere (the air that surrounds the earth and is held to it by gravity). Naturally, as one goes higher in the atmosphere, air pressure decreases because there is less air above that point and less weight. Atmospheric pressure also varies due to the amount of water vapor (humidity) in the air, wind, temperature, and other factors. But, air that is compressed or heated will exhibit more pressure than an equal volume of air that is not compressed or heated. If an opening is provided, the air with the greater pressure will flow to the air of the lower pressure.

- **Forced-air system**—System that uses moving air that is made to move through the use of fans, blowers, impellers, and similar devices

  Examples: Leaf blowers, cooling fans, ultralight aircraft

  Note: Forced air is air that has been made to move, such as the cooling air forced across an engine body by the vanes on a flywheel.

Information Sheet

- **Air-suction system**—System that uses air that is at a pressure less than the pressure of the surrounding atmospheric air

  Examples: Lawn vacuums, snow blowers, paint sprayers

  Note: The terms *suction* and *vacuum* are frequently used in reference to systems and operational characteristics of power product equipment. Both terms refer to the use of air-pressure differentials. When there is a difference of pressure between two volumes of air or gas that are open to each other, the air or gas in the volume of higher pressure will flow into the volume of lower pressure until the two volumes have equalized pressure. While in the scientific community the term *vacuum* is used to refer to a volume that is completely empty of air or gases, within most technical fields the term is used to indicate any volume of lower pressure. Similarly, the term *suction* is used to describe the flow of gases from a high-pressure volume to a low-pressure volume, even though it is the expansive force of the higher pressure that produces the movement of air.

- **Hydrodynamic system**—System that uses moving liquids that are not recirculated

  Examples: Water pumps, jet skis, outboard motors, power sprayers

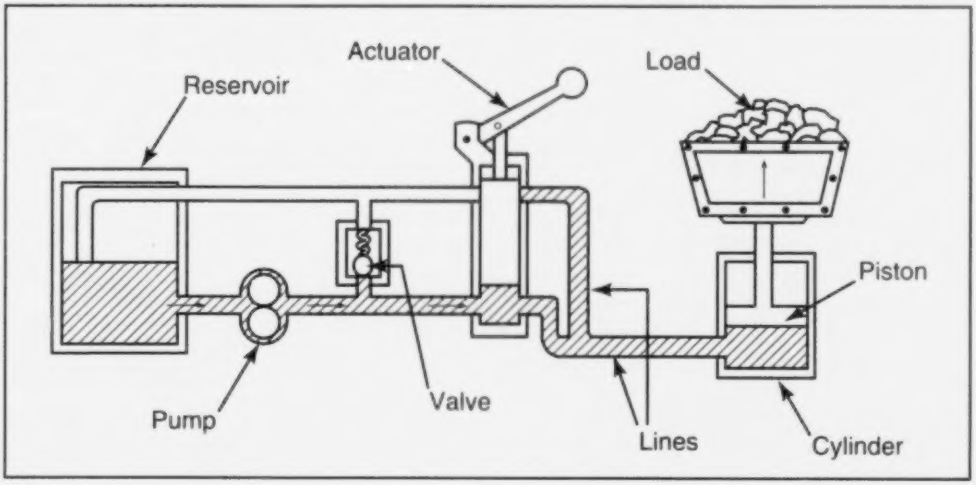
- **Hydrostatic system**—System that uses stationary liquids or uses moving liquids that are recirculated

  Examples: Hydraulic transmissions, hydraulic brake systems, power-steering systems, hydraulic lift systems, hydraulic equipment drives

3. **Major components of hydraulic systems and their functions** (see Figure 1)

Note: Every hydraulic system must have a means of applying pressure to the fluid, directing and controlling the results of that applied pressure, and transmitting hydraulic force outside the system. The force applied to move an object is referred to as a *load*. The components illustrated in Figure 1 and discussed on the next page are designed to provide those capabilities.

Figure 1: Major components of hydraulic systems



Information Sheet

- **Reservoir**—Holds the fluid that is not in use in other parts of the system

  Note: Normally, the fluid in a reservoir is not under any pressure other than gravity and atmospheric pressure. Some hydraulic systems use accumulators, which store fluid that has been pressurized through the operation of the system.

- **Pump**—Moves the fluid from the reservoir to the rest of the system and provides pressure to the system

  Note: Pumps are most commonly used with lift and ram hydraulics and for power-steering systems in power product equipment. Some systems, such as brake systems, use piston movement or diaphragms rather than pumps to move fluid from the reservoir and to supply pressure.

- **Actuator**—Provides a means for the operator to control the operation of the hydraulic system

  Examples: Brake pedal, lift lever, steering wheel

  Note: An actuator normally applies pressure to the system, as in the case of a brake pedal, or positions valves to direct the flow of hydraulic fluid within the system.

- **Lines**—Connect the parts of the system and hold the fluid

  Note: Hydraulic lines are normally made of steel or reinforced rubber. Metal lines are usually referred to as *lines*, while rubber lines are usually referred to as *hoses*. Connectors are usually made of steel or brass.

- **Cylinder**—Houses the piston and holds the fluid

- **Piston**—Moves in response to fluid pressure or actuator operation to produce the mechanical or fluid movement

- **Valves**—Control the routing of the fluid through the system in response to differences in pressure or mechanical adjustments

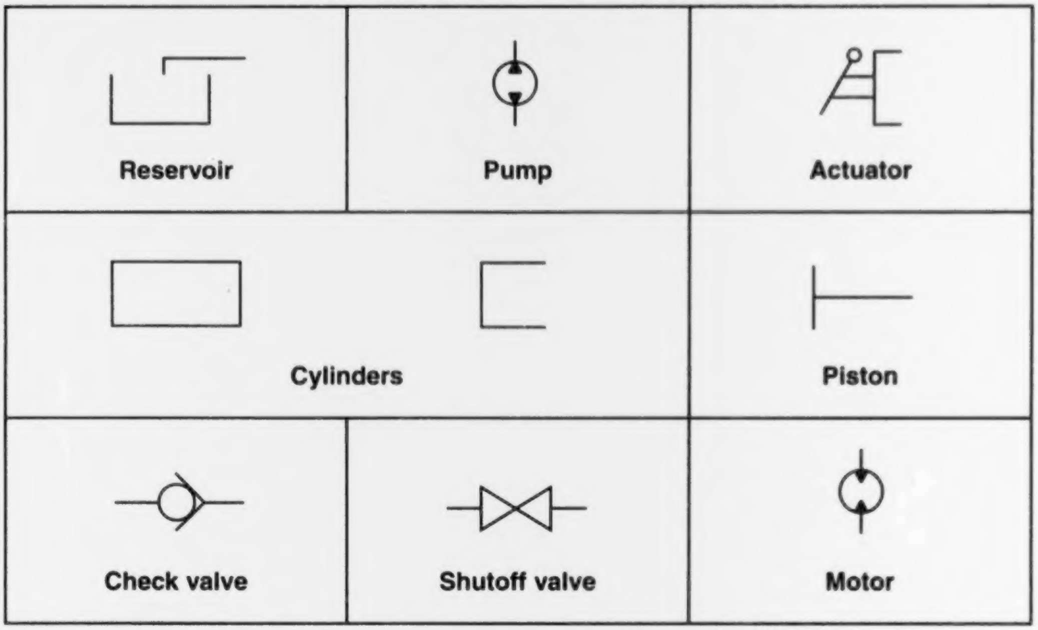
  Note: Valves in hydraulic systems are normally used to control one of three aspects of fluid flow: (1) a valve may open or close at a given pressure, thus regulating flow based on pressure; (2) a valve may regulate flow by restricting or increasing the volume in a hydraulic line, thus regulating rate of flow based on volume; (3) a valve may change the path of flow based on its position, opening or closing ports as required. Some components may serve more than one purpose, including those control features that are usually performed by valves. For example, in the system illustrated in Figure 1 on page 103, the actuator piston acts as a directional control valve. The valve in the center of the illustration is called a *check valve.* Because it is spring-loaded, the check valve serves as both a flow and pressure control.

4. **Common symbols used on hydraulic diagrams** (see Figure 2 on the next page)

Note: Hydraulic diagrams are used to graphically represent the relationship of hydraulic-system components, the status of those components, fluid pressures, and other conditions of a hydraulic system for various states of operation. Symbols are used to represent the components, while colors or patterns are often used to represent fluid, to show its pressure, or to show its movement (see the flow diagrams presented in Assignment Sheet 1).

Information Sheet

Figure 2: Common symbols used on hydraulic diagrams



5. Types of hydraulic fluids used in power product equipment and their descriptions

Note: Some fluids used in power product equipment are specifically formulated for a given application, such as brake fluid is formulated specifically for brakes. The suitability of a fluid for any application depends on the viscosity of the fluid, its performance under heat conditions, its resistance to contamination such as water, flow characteristics, and other factors. If a system is simple—consisting of mostly straight, short lines and the pressure directly applied by a single piston—fluid requirements are fairly simple. If the system contains numerous, complex valves, hoses with many bends and connections, multiple pistons, sensitive pumps, and other components that demand specific fluid characteristics, the fluids must be more carefully designed to meet the system requirements.

- **Hydraulic oil**—Fluid normally used in the mechanical-drive systems of some lift systems and in hydraulic motors
- **Automatic-transmission fluid**—Fluid specifically formulated for hydrostatic transmissions but also used in some lift systems and some power-steering systems
- **Brake fluid**—Fluid that meets Department of Transportation specifications for use in automotive brake systems and is also used in power product equipment brake systems

  Note: Automotive brake-fluid manufacturing is regulated by the Department of Transportation (DOT). Most power product equipment manufacturers who offer equipment with hydraulic-brake systems recommend DOT-rated fluids. DOT-rated fluids are designated by type numbers, such as 3 and 5. These numbers represent the temperature, water-absorption characteristics, and other features.

- **Power-steering fluid**—Fluid specifically formulated for power-steering systems

Information Sheet

- **Special-application oil**—Fluid specifically recommended by an equipment manufacturer because it has been designed to meet the exact specifications of an application of a piece of equipment

  Note: Most power product equipment manufacturers offer a variety of fluids and lubricants that are marketed under the manufacturer's name. This does not necessarily mean that the product is specifically formulated for the equipment application, even if the service manual lists the product. However, in other cases, a special-application oil is actually formulated for a specific system and should be used in those applications.

- **Crankcase oil**—Fluid normally used as an engine lubricant and is also sometimes used in some hydraulic motors

6. Safety rules for working with hydraulic systems

Note: Technicians should follow the safety rules below to prevent personal injury when working with hydraulic systems.

- **Do not expose hydraulic fluids to flames, sparks, or heat.**

  Note: Most hydraulic fluids are petroleum-based and are flammable in their liquid form. These fluids become even more flammable when the fluid escapes from a hydraulic line and mixes with air to create a fine mist.

- **Remove pressure on a hydraulic system before working on any system component.**

  Examples: Lower a lift system; shut off a pump

  Note: If a hydraulic system is left under pressure when a line is removed or a connector loosened, the technician can be injured by the force of the fluid spraying from the system. Also, equipment—such as a lift that is positioned with hydraulic power—may move and injure the technician when pressure is relieved from the system.

- **Be careful when working with hydraulic seals and hoses that may cause the technician to come in contact with hot, high-pressure hydraulic fluids.**

  Note: Hydraulic systems may operate at pressures of several hundred thousand psi. Most hydraulic systems that are used in power product equipment operate at pressures of 500 to 15,000 psi. Hydraulic-system hoses can rupture and break loose and seals can blow. Hydraulic fluids escaping from ruptured hoses and blown seals are also under high pressure and may be hot if the system has been operating. Therefore, escaping hydraulic fluids can cause serious injury to the technician—cut and burn flesh, get under the skin, and damage sensitive organs such as the eyes and ears. Many facilities require technicians to wear full face shields when servicing hydraulic systems.

- **Use a light cloth or sheet of paper to locate hydraulic-system leaks; do not use your hands.**

  Note: Escaping fluid can exert pressures of several thousand psi. To avoid injury from escaping fluids when trying to locate leaks, pass a light cloth or sheet of paper along the hydraulic lines; escaping fluid will stain the cloth/paper or cause the cloth/paper to move.

Information Sheet

7. **Guidelines for preventing equipment damage when working with hydraulic systems**

- **Make sure that connections are correct and tight before pressurizing a hydraulic system.**

  Note: Connectors used in hydraulic systems are usually made of soft brass and have fine threads that can be easily stripped when tightened by the technician. Therefore, a connection may look tight but still not be secure.

- **Do not reuse fluids that have been drained from a hydraulic system.**

- **Do not contaminate hydraulic fluids with dirt or oils.**

  Note: Avoid introducing dirt and oils into the system at connections, valves, and other openings.

- **Bleed air from the system as recommended by the manufacturer after service.**

- **Do not allow fluids to contact painted or plastic surfaces.**

  Note: Hydraulic fluids—brake fluid in particular—can damage equipment finishes and some plastics.

8. **Types of power product equipment that use hydraulic power**

- **Self-propelled equipment**

  Examples: Riding lawn mowers, garden tractors, all-terrain vehicles, motorcycles

  Note: Some types of self-propelled equipment use hydraulic power for power transmission from the engine to the drive wheels. Hydraulic systems may also be used to help stop and steer such systems. Additionally, there are minor applications of hydraulic principles in shock absorbers and other components.

- **Lift equipment**

  Examples: Front-end loaders for garden tractors, leveling equipment

  Note: Lift equipment includes those types of equipment designed to lift objects and materials and those designed to raise or stabilize the equipment or its attachments. For example, fork lifts and front-end loaders lift and carry loads, usually at the front of the equipment. Three-point hitches are capable of raising and lowering attachments such as plows, tillers, and post-hole diggers at the rear of the equipment. Some types of power product equipment, especially those with digging and trenching attachments, have stabilizers called *outriggers* that extend from the equipment to help level the equipment and keep it from tipping over as weights shift during operation.

- **Ram equipment**

  Examples: Log splitters

  Note: Many hydraulic systems, including most lift systems, have rods that extend from the hydraulic piston as a mechanical connection to the equipment. The pistons and extensions are often referred to as *rams*. However, some types of equipment are designed to produce a ramming action as part of their operation. For example, in order to provide the power necessary to separate wood, log splitters generally use an internal-combustion engine to create the power and a hydraulic system to multiply the power.

- **Independent hydraulic attachments**

  Examples: Hydraulic mower decks, trailers with lift systems

  Note: Some attachments are equipped with their own hydraulic systems. Power is provided to these systems in one of two primary ways. (1) A mechanical connection such as a PTO shaft may be connected to the equipment to drive a hydraulic motor, or (2) a line may be connected between the power product equipment's hydraulic system and the attachment's hydraulic system.

9. Applications of hydraulic systems in power product equipment

Note: The major hydraulic applications in power product equipment are equipment-drive systems and hydrostatic drive trains. The common automotive hydraulics systems—brakes, power steering, and automatic transmissions—have limited applications on power product equipment and are primarily found on motorcycles and some specialized all-terrain and similar vehicles.

- **Brake systems**

  Note: Brake systems are used to stop, slow, and hold in place self-propelled equipment.

- **Hydrostatic transmissions/transaxles**

  Note: Hydrostatic transmissions/transaxles are used to transfer force from the engine to the drive axle.

- **Power-steering systems**

  Note: Power-steering systems are used to reduce the amount of operator effort required to steer self-propelled equipment.

- **Lift systems**

  Note: Lift systems are used to raise and lower extensions of or attachments to the equipment. There are basically three lift applications commonly used on power product equipment. (1) Equipment such as forklifts and front-end loaders are designed to pick up and raise loads that are not part of the equipment or an attachment to it. (2) Three-point lift systems and similar hydraulic applications raise and lower attachments to the equipment, such as plows, mower decks, and snow blades. (3) Some types of power product equipment and attachments are equipped with lift systems that are used to level, raise, or stabilize the equipment itself. Trailers and work platforms, such as cherry-pickers and power scaffolding, often use leveling systems and may have lift-and-lower capabilities. Equipment used to dig holes and trenches often have stabilizers that help balance the equipment against shifting loads.

- **Ram systems**

  Note: Ram systems are designed to apply pressure to split, crush, or compress materials. Rock crushers and concrete tampers use ram systems as do log splitters.

- **Hydraulic equipment drives**

  Note: Some equipment, including some mower decks, operate on hydraulic pressure. Rotary or other power output is provided by a hydraulic motor. The power source for the hydraulic system may be a dedicated pump that is powered directly or indirectly by the engine, or a hose may be run from another hydraulic system to provide pressure to the motor.

Information Sheet

- **Shock-dampening systems**

  Note: Some operator-ridden equipment, especially that designed for use over rough terrain, may be equipped with hydraulic shock absorbers. These devices are basically hydraulic pistons in chambered tubes that dampen the force produced as a vehicle goes up and down over rough surfaces. Shock absorbers are generally replaceable components that require no service other than periodic inspection. However, some shock absorbers have air chambers that must be charged and can be adjusted.

10. Types of hydraulic pumps

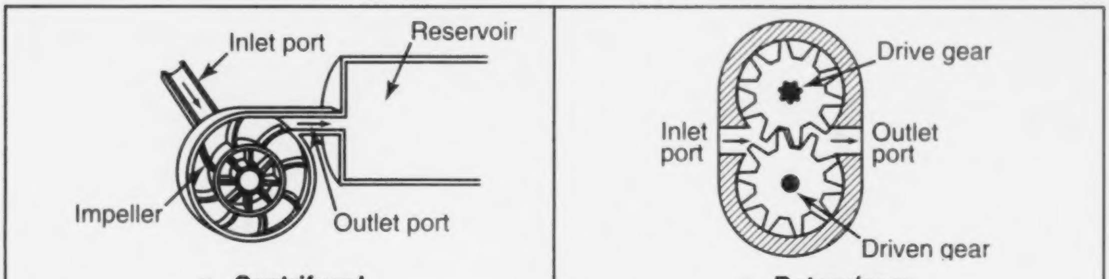
- **Centrifugal** (see Figure 3-a)

  Note: Each type of centrifugal pump works on the same principle—the rotation of the pump impeller causes fluid to flow out from the center of rotation to the perimeter of the pump body. Centrifugal force causes a substance in rotary motion to move outward from the center of rotation. Centrifugal hydraulic pumps in power product equipment are primarily used for equipment-drive systems. There are numerous variations in the design of centrifugal impellers.

- **Rotary** (see Figures 3-b, 3-c, and 3-d)

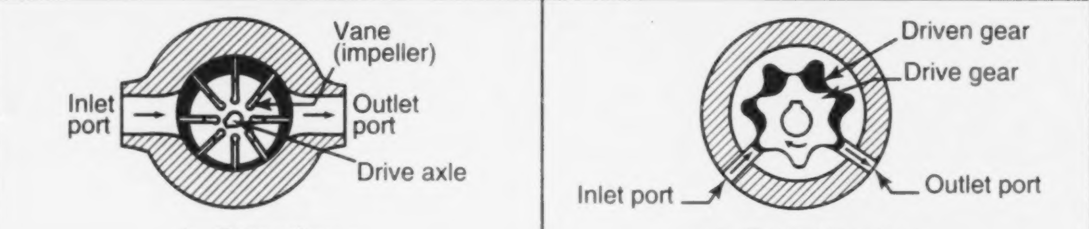
  Note: Rotary pumps belong to a family of pumps called *displacement pumps.* They work by moving fluid with vanes or teeth so that a low-pressure area is created into which other fluid flows. One of the more-common rotary designs is illustrated in Figure 3-b. It is called a *vane-design rotary pump* or simply *vane pump.* This design uses springs to keep the impeller blades (vanes) extended. Two other common designs of rotary pumps are also illustrated in Figure 3. In the gear-design rotary pump (see Figure 3-c), the gears squeeze the fluid between them, while in the gerotor design (see Figure 3-d), the gear is offset from the center of the pump body so that fluid is squeezed between the gear and the narrowing space between it and the pump body. Rotary pumps serve as charge pumps in many hydrostatic drive-train systems.

Figure 3: Types of hydraulic pumps



a. **Centrifugal**

c. **Rotary/gear**



b. **Rotary/vane**

d. **Rotary/gerotor**

Information Sheet

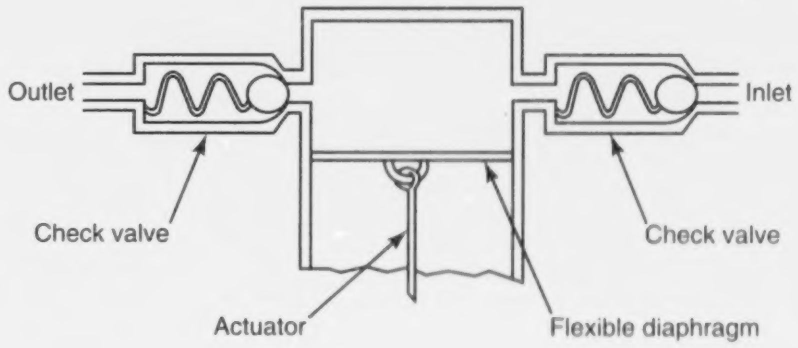
- **Diaphragm** (see Figure 4-a)

  Note: You are familiar with the operation of diaphragm pumps from your study of fuel systems. Diaphragm pumps contain a flexible membrane (diaphragm) and move fluids through the use of the changing volume of a chamber as the membrane flexes under the power of a reciprocating shaft (actuator).

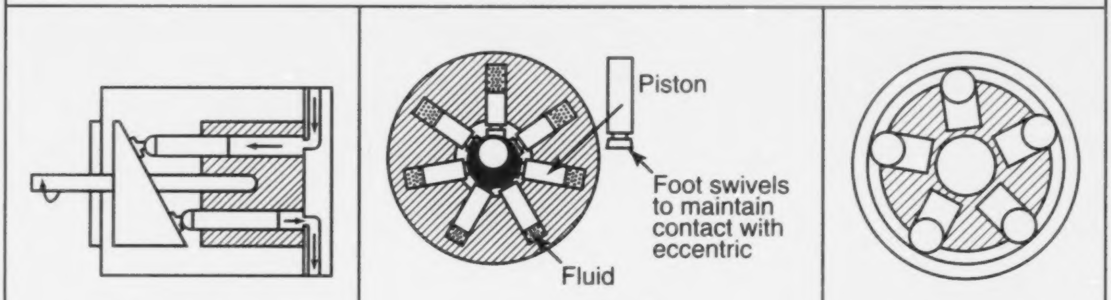
- **Piston** (see Figures 4-b, 4-c, and 4-d)

  Note: Piston pumps are commonly used in the hydraulic transmissions of power product equipment. These designs are also displacement pumps. The action of the pistons creates low-pressure areas that fill with fluid and then push the fluid through outlets. The differences in these types of pumps are the design of the pistons, the arrangement of the pistons, and how they are actuated. However, all three of these designs will have an odd number of pistons—usually 5 to 7 for ball-piston pumps and 5 to 9 for axial- and radial-piston pumps. An odd number of pistons is used to prevent the pump from locking up from balanced pressures.

Figure 4: Types of hydraulic pumps (cont.)


Outlet
Inlet
Check valve
Check valve
Actuator
Flexible diaphragm

a. **Diaphragm**


Piston
Foot swivels to maintain contact with eccentric
Fluid

b. **Piston/axial**

c. **Piston/radial**

d. **Piston/ball**

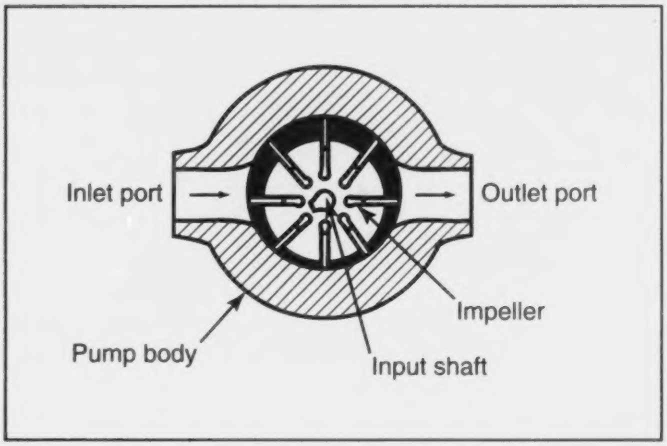
Information Sheet

11. **Major components of hydraulic pumps and their functions** (see Figure 5)

Note: While the pump shown below is specifically a vane-design pump, it is representative of most hydraulic pumps in that they have common components. Hydraulic pumps differ primarily in how they move fluid from the inlet to the outlet. All of the pumps use pressure differences to help move the fluid, with some degree of centrifugal force at work in all of the designs that use a rotating impeller.

- **Inlet port**—Allows fluid to enter the pump
- **Pump body**—Houses the pump components
- **Input shaft**—Provides the power for pump operation
- **Impeller**—Produces movement in the fluid
- **Outlet port**—Allows fluid to exit the pump

Figure 5: Major components of hydraulic pumps



12. **Principles of operation of centrifugal hydraulic pumps** (see Figure 3-a on page 109)

- An outside source, such as an engine, provides rotational force that is transmitted to the pump.
- The rotational force causes an impeller within the pump to turn.
- The impeller moves fluid near its axis, and centrifugal force causes the fluid to move toward the outside edge of the impeller and through the outlet (outlet port).
- The changes in pressure caused by the moving fluid allow additional fluid to flow into the pump through an inlet opening (inlet port).

Information Sheet

13. **Principles of operation of rotary hydraulic pumps** (see Figures 3-b, 3-c, and 3-d on page 109)

    - An outside source, such as an engine, provides rotational force that is transmitted to the pump.
    - The rotational force causes a wheel, such as a gear, within the pump to turn.
    - The turning gear moves fluid and pushes it from an open area of the pump body to a narrower area of the pump (a second gear or a constricted portion of the pump).
    - The fluid in the constricted area moves faster, causing the pressure to decrease so that fluid flows in behind the moving fluid.

14. **Principles of operation of diaphragm hydraulic pumps** (see Figure 4-a on page 110)

    - Force from an outside source, such as an engine, is applied as a reciprocating motion to a flexible diaphragm.
    - The movement of the diaphragm causes the volume of the pump chamber to alternately increase and decrease.
    - When the pump-chamber volume increases, fluid flows into the pump through an inlet opening that is usually equipped with a one-way valve.
    - When the pump-chamber volume decreases, fluid is forced through an outlet opening that is equipped with a one-way valve.

15. **Principles of operation of piston hydraulic pumps** (see Figures 4-b, 4-c, and 4-d on page 110)

    Note: Because of the important role piston pumps play in the operation of hydrostatic drive trains, their operation is explained in more detail in Unit 4, "Hydraulic and Pneumatic Drive Systems."

    - An outside source, such as an engine, provides force—usually rotational—that is transmitted to the pump.
    - The force causes pistons in one or more cylinders to move back and forth.
    - The movement of a piston causes the volume of the cylinder to change.
    - As the volume of the fluid side of the cylinder increases, fluid flows into the cylinder.
    - The continued rotation of the pump or of a mechanical device such as a spring causes the piston to move back in the cylinder.
    - As the piston returns to decrease the volume on the fluid side of the cylinder, fluid is forced out of the pump.

Information Sheet

16. Typical service procedures required for hydraulic systems

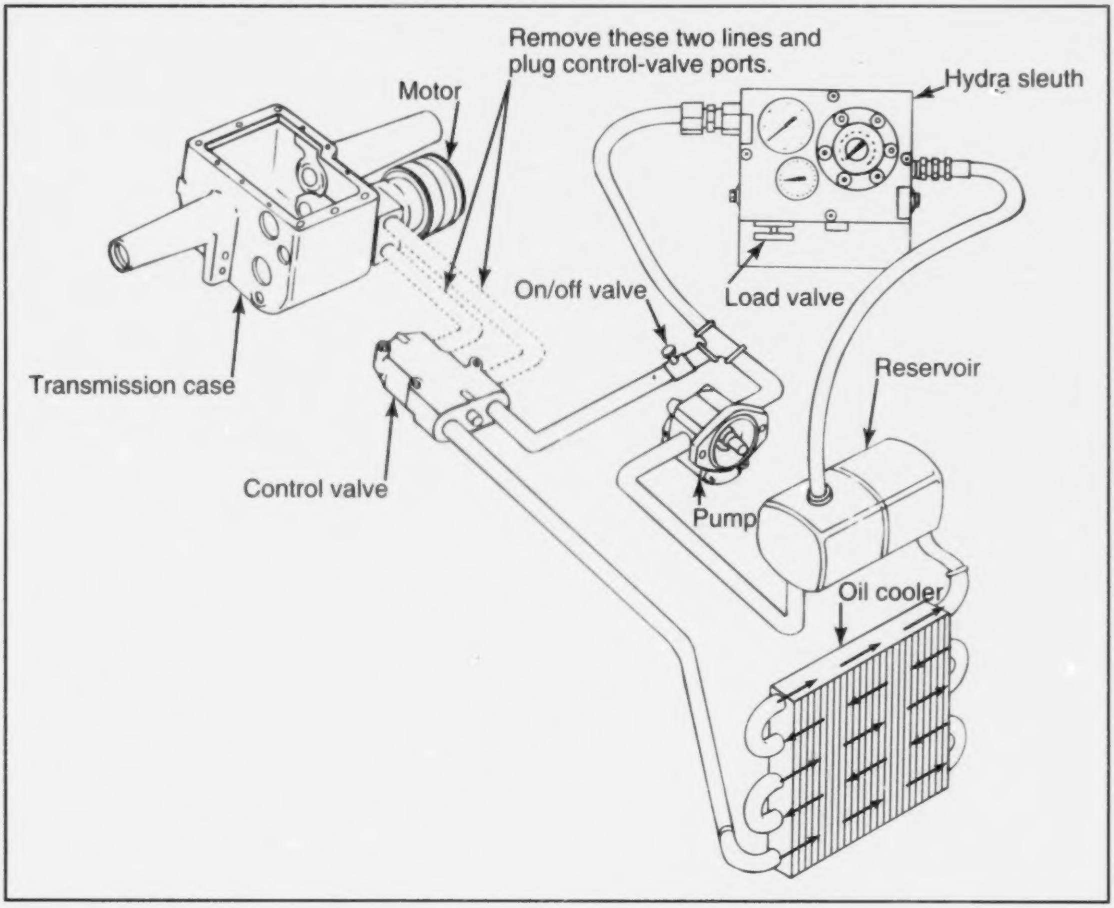
- **Measure fluid temperature**

  Note: Hydraulic fluid heats as it circulates, which causes it to thin and become less effective in transmitting force. This is one reason for having a reservoir rather than having just enough fluid to fill the system. Other hydraulic circuits have coolers through which the fluid circulates and where it is cooled by air passing through the cooler. Measuring fluid temperature can tell you much about the operating efficiency of the system and of the coolers.

- **Measure system pressure**

  Note: Hydraulic systems are designed to operate within specific pressure ranges. Most are equipped with relief valves that open to release fluid if the pressure gets too high. Pressure can be tested for a system or for portions of a system. Although some systems may have in-line pressure gauges, pressure is normally measured by installing a by-pass line with a pressure gauge, as shown in Figure 6 below.

Figure 6: Measuring system pressure


Remove these two lines and plug control-valve ports.
Motor
Hydra sleuth
On/off valve
Load valve
Transmission case
Reservoir
Control valve
Pump
Oil cooler

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Information Sheet

- **Measure flow**

  Note: Flow is normally measured in gallons per minute (gpm) and is only applicable to those systems that recirculate fluid—that is, those systems that have pumps. For example, brake systems and lift systems generally use pistons to push fluid short distances through the system, while hydrostatic drive trains move fluid through the system with pumps as long as the engine is running.

- **Bleed the system**
- **Flush the system**
- **Replace seals**
- **Replace hoses and lines**

17. **Specialty tools used to perform hydraulic-system service**

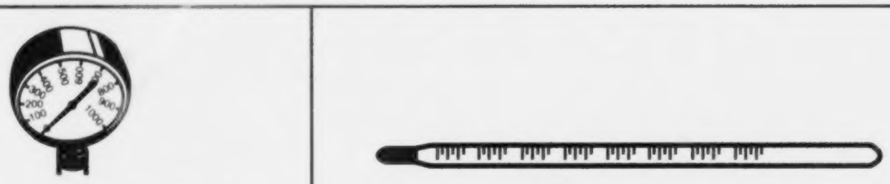
Note: To measure characteristics of a hydraulic system, normally the technician must access fluid within the system. To permit such access, many manufacturers produce by-pass assemblies that route fluid through a device that can measure features such as pressure and flow.

- **Pressure gauge** (see Figure 7-a)

  Note: A technician must be careful to use a pressure gauge that is capable of withstanding the pressures that will be exerted by the system.

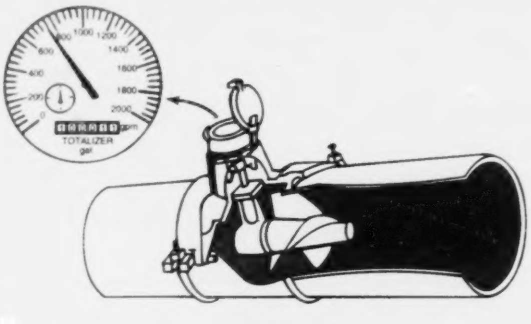
- **Thermometer** (see Figure 7-b)
- **Fluid flow meter** (see Figure 7-c)

Figure 7: Specialty tools



a. **Hydraulic-pressure gauge**

b. **Hydraulic thermometer**



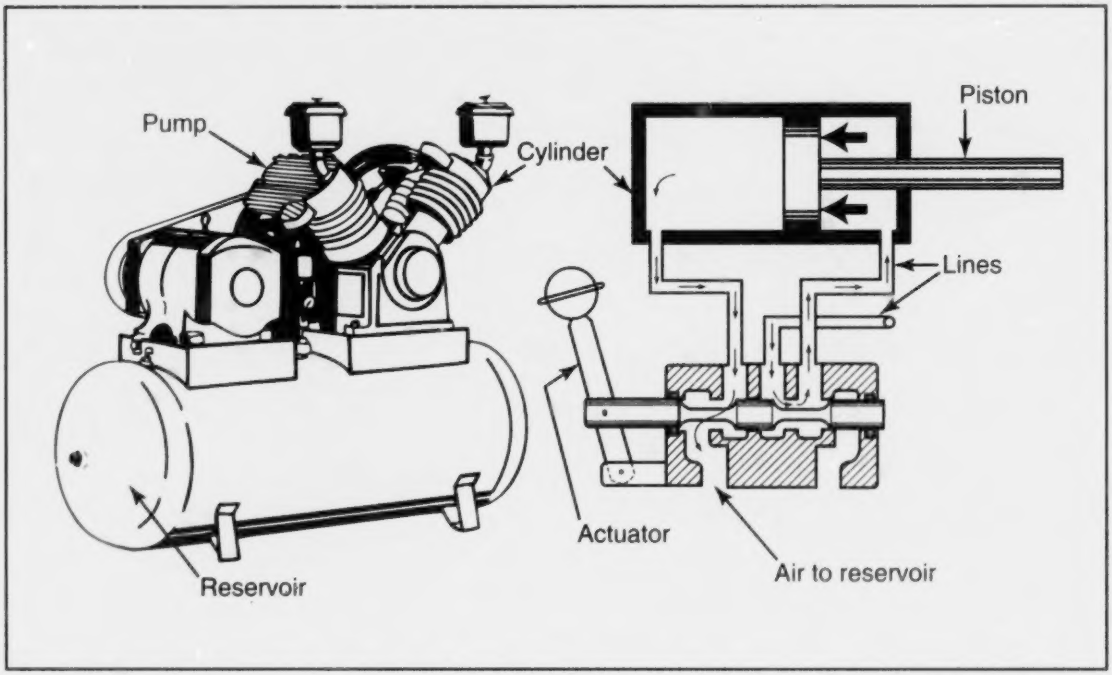
c. **Flow meter**

Information Sheet

18. Major components of pneumatic systems and their functions (see Figure 8)

Note: Pneumatic systems resemble hydraulic systems. Both systems have somewhat the same components that function in much the same way. The system shown in Figure 8 is a true pneumatic system that uses compressed air. Other pneumatic systems may use blowers or fans in place of pumps to move air and will not require the use of valves or a reservoir. Both types may be powered by internal-combustion engines.

Figure 8: Major components of pneumatic systems



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- **Reservoir**—Holds air under pressure

  Note: In many closed systems, the reservoir holds air that has been pumped into it under pressure. When air is compressed, two important changes take place in it. First, air heats as it is compressed due to packing the same amount of energy into a smaller space. While the heat is not generally sufficient to burn flesh, it is warm enough to be painful and may cause an accident if a technician is surprised by contacting the hot surface. Second, compressed air is not able to hold as much water vapor as was contained in the expanded air. Thus, water accumulates in the reservoir and must be drained, often daily.

- **Pump**—Moves air under pressure into the reservoir

  Note: The pump system includes an engine as a source of power. The pump may be mounted directly to the output shaft as a blower, or it may be linked mechanically as a blower or as a compressor. In very low-pressure systems and forced-air systems, blowers are normally used to move air. In compressed-air systems, the pump moves air into a confined space.

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- **Actuator**—Provides a means for the operator to control the operation of the pneumatic system

  Examples: Shutoff valve, trigger

  Note: Pneumatic-equipment actuators provide control over pump operation and the release of air or its direction of flow. Actuators may be automatic or manual. Most pneumatic reservoirs are equipped with shutoff valves at their outlets. Additional shutoff valves may be provided in the system so that pressurized air may be released into a portion of the system. Another common actuator in pneumatic systems is a trigger. The operator may squeeze the trigger to release air or to control a tool, such as a pneumatic wrench.

- **Lines**—Connect the parts of the system and hold the pressurized air, or direct moving air

  Note: Pneumatic lines are generally reinforced rubber and are, therefore, normally referred to as *hoses*. Connections are generally steel or brass. Connectors are usually equipped with rubber seals to provide airtight connections. The flow path of the air may also be directed by exhaust tubes, chutes, shaped housings, and other components.

- **Cylinder**—Houses the piston

- **Piston**—Moves in response to an outside power source to take air into the cylinder, compress it, and force it into the reservoir

  Note: The piston and cylinder are part of the pump in some compressed-air systems—reciprocating-pump systems in particular. A diaphragm pump uses a flexible membrane for its piston. Many open forced-air systems do not use pistons and cylinders.

- **Valves**—Control the routing of air through the system in response to differences in pressure or mechanical adjustments

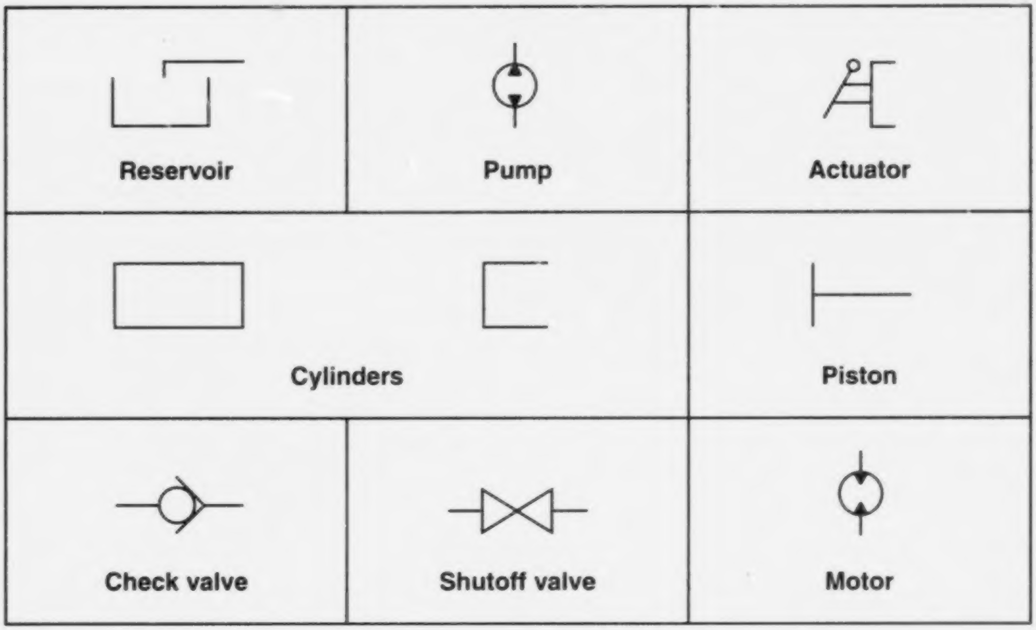
  Note: Valves in pneumatic systems are normally used to control one of three aspects of airflow. (1) A valve may open or close at a given pressure, thus regulating flow based on pressure. (2) A valve may regulate flow by restricting or increasing the volume in a line, thus regulating rate of flow based on volume. (3) A valve may change the path of flow based on its position, opening or closing ports as required. In forced-air systems, dampers and vents are used to direct airflow.

19. **Common symbols used on pneumatic diagrams** (see Figure 9 on the next page)

Note: Airflow diagrams are used to graphically represent the relationship of pneumatic-system components, the status of those components, air pressures, and other conditions of a pneumatic system for various states of operation. Symbols are used to represent the components, while colors or patterns are often used to represent air pressure. Most of the symbols are the same as those used for hydraulic diagrams.

Information Sheet

Figure 9: Common symbols used on pneumatic diagrams



20. Safety rules for working with pneumatic systems

- **Do not direct airstreams toward yourself or other persons.**

  Note: Most power product equipment pneumatic systems operate at relatively low pressures (generally less than 150 psi) and would not normally cause injury from pressure alone. However, surprising someone with a stream of air can lead to an accident. Even low-pressure air can blow dirt, metal filings, small tools and parts, and other objects toward a person and cause injury.

- **Remove air pressure before working on any system components.**

  Examples: Shut off reservoir and bleed air from lines; operate equipment until air pressure is equalized

  Note: While the air pressure in a pneumatic system is low, leaving the system pressurized can blow a hose off its connection or blow out a seal, either of which can cause injury. Also, a pressurized system may operate equipment unexpectedly and injure the technician.

- **Be careful when working with pneumatic hoses and seals.**

  Note: Extremely high-pressure air systems can cause serious injury. Air under pressure can cut flesh, get under skin, and damage sensitive organs such as eyes and ears. The pressure may also create the danger of flying objects from ruptured hoses and blown seals. Many power product equipment air systems can be powerful enough to blow objects through the air with a great deal of force or to cause hoses to whip around, and in some cases, these systems produce forces high enough to rupture the skin with air alone.

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- **Use a light cloth or sheet of paper to locate pneumatic-system leaks; do not use your hands.**

  Note: To avoid injury from escaping air when trying to locate leaks, pass a light cloth or sheet of paper along the pneumatic lines, escaping air will cause the cloth/paper to move.

- **Never use oxygen or other pressurized gases in place of compressed air.**

  Note: Oxygen is explosive and flammable, as are many other gases. These gases are especially dangerous when they mix with oil or grease that may contaminate a pneumatic system.

21. Guidelines for preventing equipment damage when working with pneumatic systems

- Make sure that connections are correct and tight before pressurizing a pneumatic system.
- Do **not** contaminate pneumatic hoses, connectors, or reservoirs with dirt, grease, water, or any other contaminant.

22. Types of power product equipment that use pneumatic power

- **Lawn mowers**

  Note: Lawn mowers use suction systems to lift the grass and forced air to discharge it. Moving air creates areas of low pressure that serve as suction to lift the grass. When the moving air is pushed through the restriction of the discharge chute, air speed increases, causing the air to move out with greater power.

- **Snow blowers**

  Note: Most snow blowers operate by chopping the snow into small pieces that are pushed up through an impeller and forced out through a discharge chute.

- **Leaf blowers**

  Note: Leaf blowers use a fan or blower to move air through the blower body and to force it through a narrow tube to cause the airstream to increase in velocity and force. This airstream is directed by the operator to move leaves and other light debris.

- **Sprayers**

  Note: Sprayers use suction systems to draw liquids into a moving stream of air and forced air to move the mixture of liquid and air to an application area. Sprayers are used for paint and other finishes, for water, and for virtually anything that will mix with water, including fertilizers, pesticides, detergents, etc.

- **Lawn vacuums**

  Note: Lawn vacuums use the low pressure created by moving air to pick up leaves, grass cuttings, and similar debris and to discharge it into bags or hoppers.

23. Applications of pneumatic systems in power product equipment

- **Air compressors**

  Note: Air compressors are pneumatic systems. They normally use a piston to create pressurized air that is stored in a reservoir. This air is then used for other purposes, such as powering sprayers, pneumatic tools, lift systems, and other applications.

Information Sheet

- **Suspension systems**

  Note: Suspension systems are those components that are intended to support the equipment as it travels over surfaces and to generally reduce the effects of vibration on the equipment and operator. While many types of power product equipment have limited suspension systems (such as hard-rubber tires or mechanical systems such as springs), some motorcycles, garden tractors, snowmobiles, and similar equipment have shock absorbers. Most shock absorbers are hydraulic, but some are air filled or use a combination of hydraulic and pneumatic cushioning. Air-filled tires are also part of a pneumatic suspension system.

24. Types of pneumatic pumps

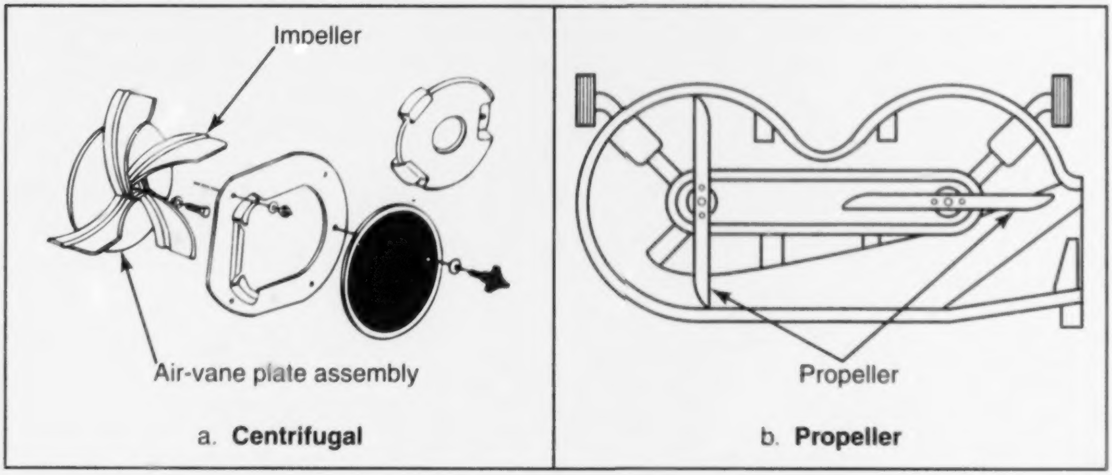
- **Centrifugal** (see Figure 10-a)

  Note: A centrifugal pump creates low-pressure areas of moving air so that air enters near the center of the pump body and uses an impeller to move air to the outside of the pump body by centrifugal force. Many personal hair dryers work on this principle, as do most leaf blowers.

- **Propeller** (see Figure 10-b)

  Note: The propeller is the pump design used for electric fans and ultralight aircraft. Propellers work by moving air on one side of the propeller, which creates an area of low pressure. Air from the other side of the propeller moves to the area of low pressure on the opposite side, thus pulling or pushing air from one side to the other. This principle works with mower blades and the impeller in snow blowers.

Figure 10: Types of pneumatic pumps



a. **Centrifugal**

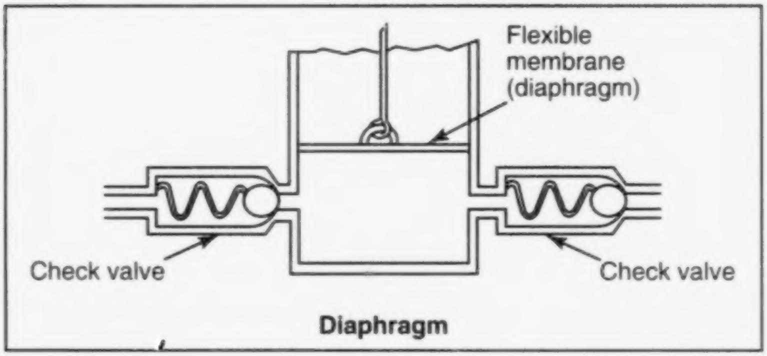
b. **Propeller**

Figure 10-a and 10-b reproduced by permission of Mike Barnett., MTD Products, Inc., Cleveland, Ohio.

- **Diaphragm** (see Figure 11)

  Note: Diaphragm pumps are just one of the variety of reciprocating pumps with the primary difference being that the piston is replaced with a flexible membrane. This is the type of hydraulic pump often used for fuel pumps and the bellows pumps used in blacksmith shops. In power product equipment, the most common air-pump applications are for sprayers and concrete pumps.

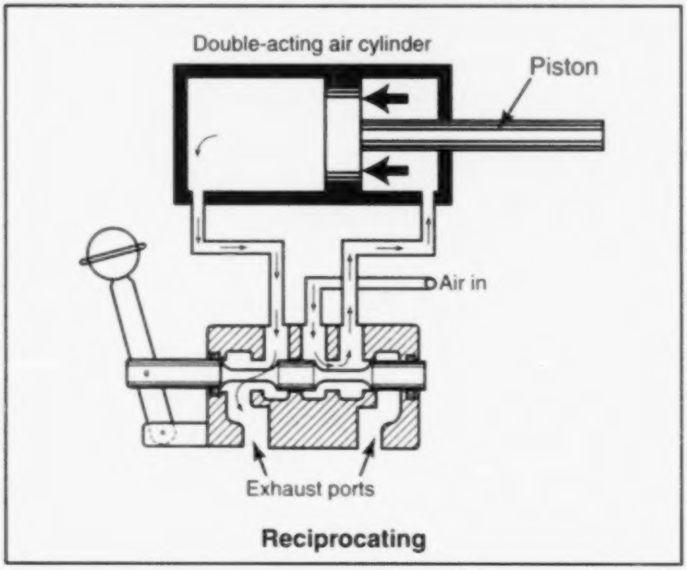
Figure 11: Types of pneumatic pumps (cont.)


Flexible
membrane
(diaphragm)
Check valve
Check valve
Diaphragm

- **Reciprocating** (see Figure 12)

  Note: While many types of pumps use reciprocating action, as used here the term applies specifically to pumps of the type commonly found in air compressors. Reciprocating pumps operate like an internal-combustion engine—the reciprocating action of the piston allows air in through one valve and pushes compressed air out a second valve, similar to the intake and exhaust strokes of an engine. This is the action used for bicycle pumps.

Figure 12: Types of pneumatic pumps (cont.)


Double-acting air cylinder
Piston
Air in
Exhaust ports
Reciprocating

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Information Sheet

25. Major components of pneumatic pumps and their functions (see Figure 13)

- **Air-inlet port**—Allows air to enter the pump

  Note: The inlet and outlet ports may simply be openings into the pump body, or they may have valves that open and close to control airflow. If used, the valves generally operate as a result of changes in pressure in the system.

- **Pump body**—Houses the pump components

- **Power input**—Drives the pump mechanism

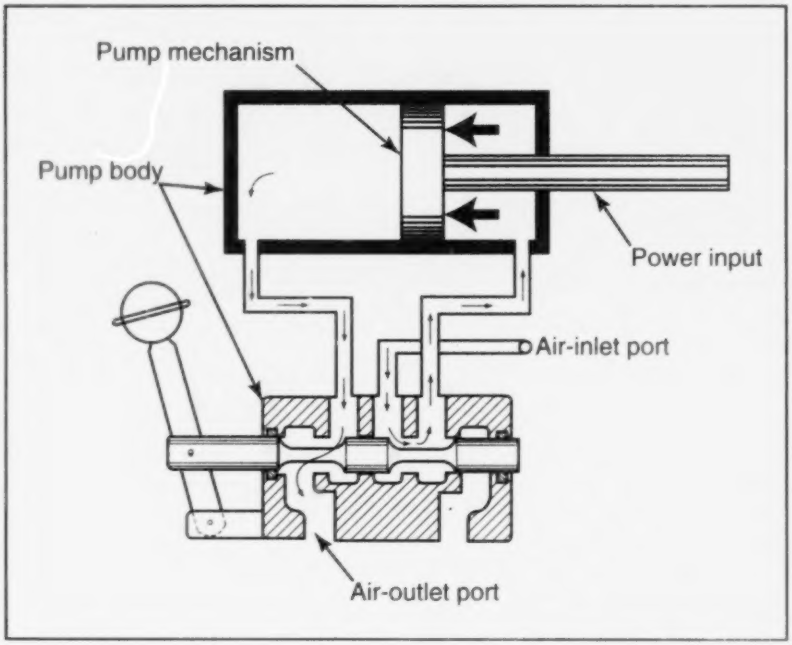
  Note: Air pumps on power product equipment are normally driven by the equipment engine. Most pumps with fan-pump mechanisms use the engine's rotary power to drive the fans. For piston pumps and diaphragm pumps, the engine's rotary output is normally converted to reciprocating motion to power the pump.

- **Pump mechanism**—Moves air through the system

  Note: For forced-air systems, the pump mechanism is generally a fan or blower often referred to as an *impeller* or *propeller*. For compressed-air systems, the pump mechanism is usually a piston.

- **Air-outlet port**—Allows air to exit the pump

Figure 13: Major components of pneumatic pumps



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Information Sheet

26. **Principles of operation of centrifugal pneumatic pumps** (see Figure 10-a on page 119)

    - An outside source, such as an engine, provides rotational force that is transmitted to the pump.
    - The rotational force causes an impeller within the pump to turn.
    - Extensions on the impeller, such as vanes, push air through the pump.
    - The changes in pressure caused by the moving air pull additional air into the pump through an inlet near the center of the pump.

27. **Principles of operation of propeller pneumatic pumps** (see Figure 10-b on page 119)

    - The propeller is turned by the engine, either directly mounted on the engine-output shaft or through a mechanical linkage.
    - The movement of the propeller pushes air on one side of the propeller, depending on the angle of the blades and the direction of rotation.
    - As the air is pushed out of the way, a low-pressure area is created.
    - Air from the back side of the propeller moves to the low-pressure area and air moves to replace that air.
    - The continued rotation of the propeller repeats the cycle of moving air to create a continuous flow as long as the engine drives the propeller.

28. **Principles of operation of diaphragm pneumatic pumps** (see Figure 11 on page 120)

    - Force from an outside source, such as an engine, is applied as a reciprocating motion to a flexible diaphragm.
    - The movement of the diaphragm causes the volume of the pump chamber to alternately increase and decrease.
    - When the pump-chamber volume increases, air is drawn into the pump through an inlet opening that is usually equipped with a one-way valve.
    - When the pump-chamber volume decreases, air is forced through an outlet opening that is equipped with a one-way valve.

29. **Principles of operation of reciprocating pneumatic pumps** (see Figure 12 on page 120)

    - An outside source, such as an engine, provides force to move the piston in the cylinder.
    - As the piston moves away from the valve, it creates low pressure in the cylinder.
    - Higher-pressure air outside the cylinder pushes the valve open so that air enters the cylinder.
    - The continued operation of the engine causes the piston to return in the cylinder.
    - The movement of the piston compresses the air in the cylinder, so that pressure increases.
    - When the air pressure in the cylinder exceeds the outside-air pressure, the inlet valve closes and the piston continues to compress the air until the pressure becomes great enough to open the outlet valve.

Information Sheet

- The continued movement of the piston pushes the air from the cylinder.
- When the piston starts back in the cylinder, pressure begins to decrease, allowing the outlet valve to close and the inlet valve to open so that air enters the cylinder.

30. Typical service procedures required for pneumatic systems

- **Lubricate moving parts**
- **Measure system pressure**
- **Measure flow**
- **Drain water from the system**

  Note: When air is pressurized, it cannot hold as much water vapor as it could before it was compressed. Additionally, as the temperature of a reservoir drops, the moisture within it condenses. Most reservoirs have drain plugs that allow the operator to drain water from the tank.

- **Drain filters**
- **Replace filters**

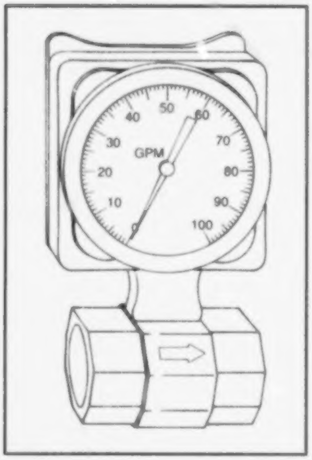
  Note: Since so many pneumatic systems draw air from the atmosphere, they are equipped with filter systems to remove dirt and other debris. Most filters are not serviceable and must be replaced, though some can be cleaned.

- **Replace seals**
- **Replace hoses and lines**

31. Specialty tools used to perform pneumatic-system service

- **Pressure gauge**
- **Airflow meter** (see Figure 14)

  Figure 14: Airflow meter



Principles of Fluid Power
Unit 3

Assignment Sheet 1—Interpret Flow Diagrams and Assembly Drawings

Name ______________________________ Date ______________

Evaluation criteria	**Rating**
Directions have been followed.	______
Minimum of 85 percent of answers are correct.	______
Overall rating	______

Evaluator's comments ____

____

____

Introduction

In order to describe the operation of fluid-power systems, engineers and technicians use two types of illustrations—flow diagrams and assembly drawings. Flow diagrams use the symbols discussed in the information sheet of this unit to represent the components of fluid-power systems. The flow diagram shows how the components are connected and often indicates the pressure level, direction of flow, or other characteristics of the system fluid. Typically, a flow diagram represents a specific configuration of the system and shows the fluid characteristics for that particular configuration, such as the pressures and direction of flow when the charge pump is operating at low pressure.

Assembly drawings show the components of an assembly or system and how they are arranged in relation to one another. Various types of views—cross-sections, exploded views, and cutaways—may be used in assembly drawings.

Both of these types of illustrations are useful in allowing service technicians to determine how a system should work and to recognize when it is not functioning properly. In this assignment sheet, you will interpret flow diagrams and assembly drawings for equipment that you are likely to service in your career as a power product equipment technician.

Assignment Sheet 1

Exercise

Directions Study the diagrams on this and the following pages and answer the questions with each illustration. Write your answers on the blank lines provided with each question, or follow the specific directions with the question.

1. The illustration in Figure 1 below shows the flow of hydraulic fluid for an Eaton Model 6 hydrostatic transmission.

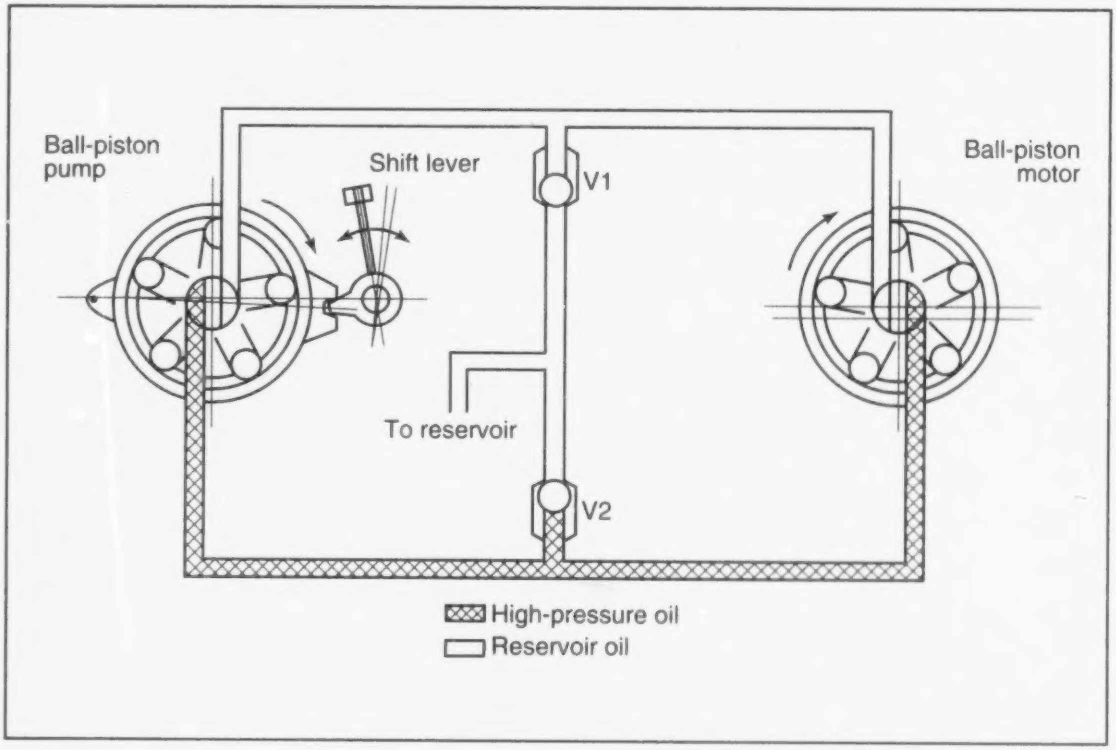
   a. Is the oil flowing past Valve 1 high-pressure oil or reservoir oil? (Circle the correct answer below.)

      High-pressure oil   Reservoir oil

   b. Is the shift lever linked to the piston pump or to the piston motor? (Circle the correct answer below.)

      Piston pump   Piston motor

Figure 1: Eaton Model 6 hydrostatic-transmission flow diagram


Ball-piston pump
Shift lever
V1
Ball-piston motor
To reservoir
V2
▨ High-pressure oil
▭ Reservoir oil

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Assignment Sheet 1

2. The illustration in Figure 2 below shows the flow of hydraulic fluid for an Eaton Model 12 hydrostatic transmission.

   a. What type of oil is represented by the solid-white coloring of the piping?

   Type of oil — ______________________________

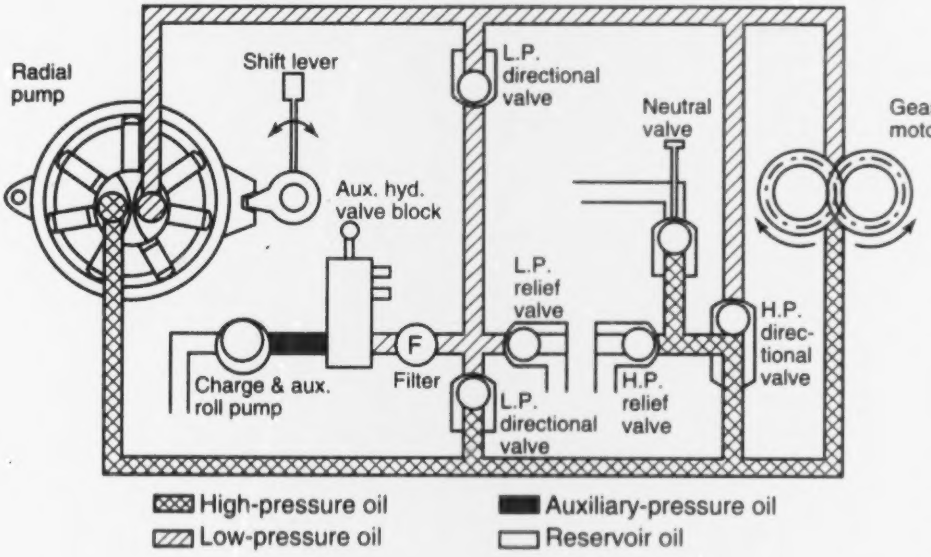
   b. Which pump provides oil from the reservoir to the low-pressure portion of the system?

   Pump — ______________________________

   c. Does this system have a filter? (Circle the correct answer below.)

   Yes No

Figure 2: Eaton Model 12 hydrostatic-transmission flow diagram


Radial pump
Shift lever
L.P. directional valve
Neutral valve
Gear motor
Aux. hyd. valve block
L.P. relief valve
H.P. directional valve
F
Charge & aux. roll pump
Filter
L.P. directional valve
H.P. relief valve
High-pressure oil
Low-pressure oil
Auxiliary-pressure oil
Reservoir oil

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Assignment Sheet 1

3. Figure 3 on the next page shows a hydraulic brake system used on some models of Kawasaki motorcycles.

   a. What solvent should be used to clean the caliper parts?

      Solvent — ______________________________

   b. What part number is the piston for this system?

      Part number — ______________________________

   c. What part number is the reservoir?

      Part number — ______________________________

   d. What type of actuator is used for this system?

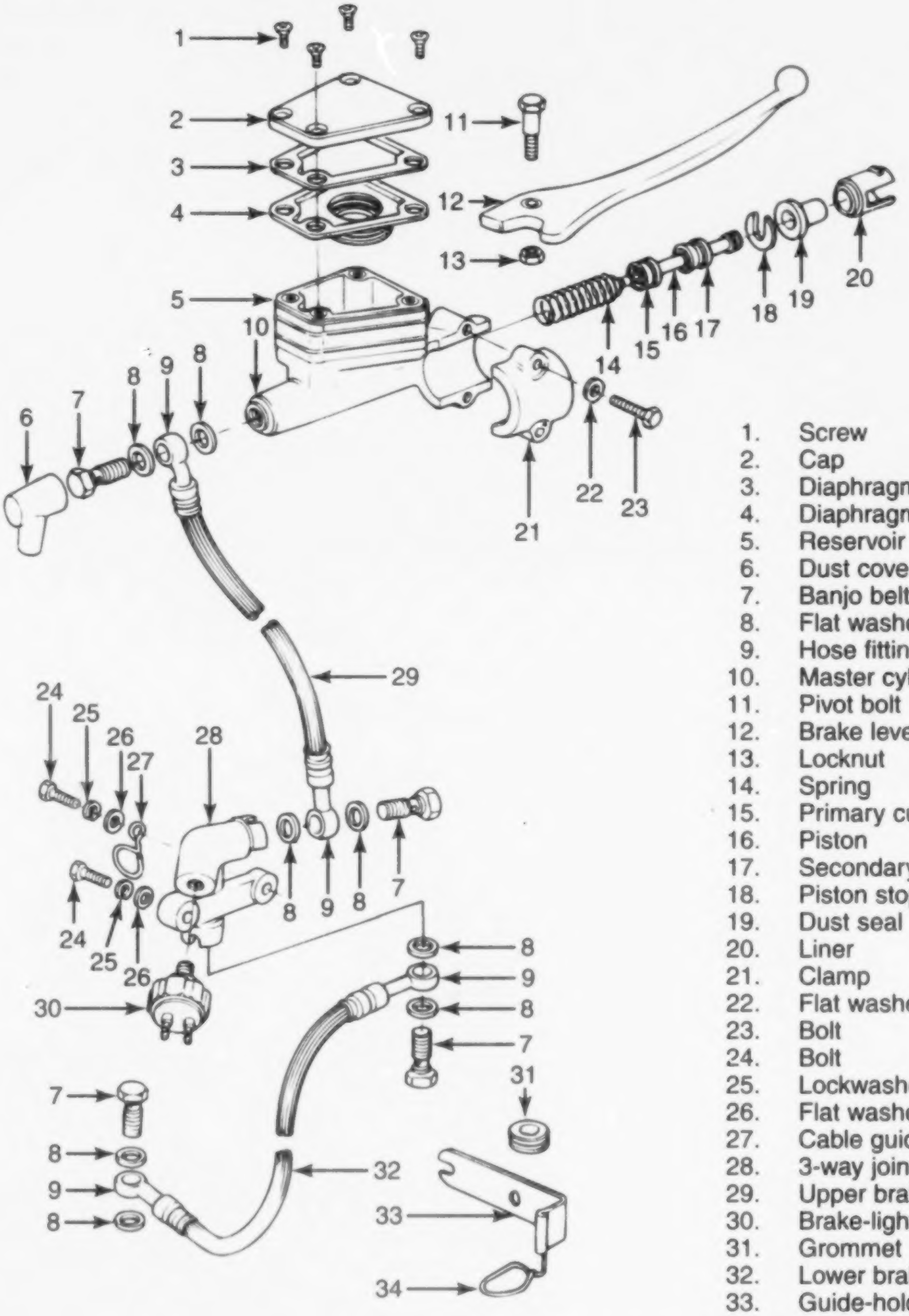
      Actuator type — ______________________________

   e. Is this a circulating or displacement hydraulic system? (Circle the correct answer below.)

      Circulating   Displacement

Assignment Sheet 1

Figure 3: Kawasaki hydraulic-brake system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1. Screw
2. Cap
3. Diaphragm plate
4. Diaphragm
5. Reservoir
6. Dust cover
7. Banjo belt
8. Flat washer
9. Hose fitting
10. Master cylinder
11. Pivot bolt
12. Brake lever
13. Locknut
14. Spring
15. Primary cup
16. Piston
17. Secondary cup
18. Piston stop
19. Dust seal
20. Liner
21. Clamp
22. Flat washer
23. Bolt
24. Bolt
25. Lockwasher
26. Flat washer
27. Cable guide
28. 3-way joint
29. Upper brake hose
30. Brake-light switch
31. Grommet
32. Lower brake hose
33. Guide-holder plate
34. Cable guide

Reproduced by permission of Kawasaki Motors Corporation, U.S.A., Irvine, California.

Assignment Sheet 1

4. Figures 4 and 5 on the next page show the control valve (Figure 4) and the hydraulic-lift cylinder (Figure 5) used on some Jacobsen garden tractors with hydrostatic transmissions.

   a. Directional control of the system fluid is provided by the spool in the control valve. What number of part is the spool?

      Part number — ____________________

   b. The control-valve screw (Item 17) threads into what part?

      Part — ____________________

   c. What is the part number of the piston in the illustration for the hydraulic-lift cylinder?

      Part number — ____________________

   d. What part is used to mount the rod and piston?

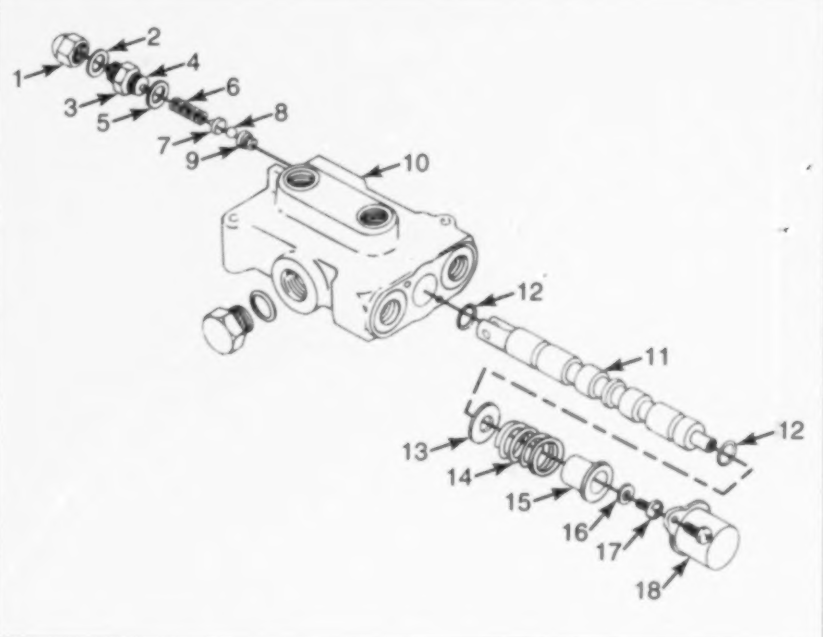
      Part — ____________________

   e. The rod guide (Item 11) fits into the end of the cylinder tube (Item 1). What item holds the rod guide in place?

      Item — ____________________

Assignment Sheet 1

Figure 4: Control valve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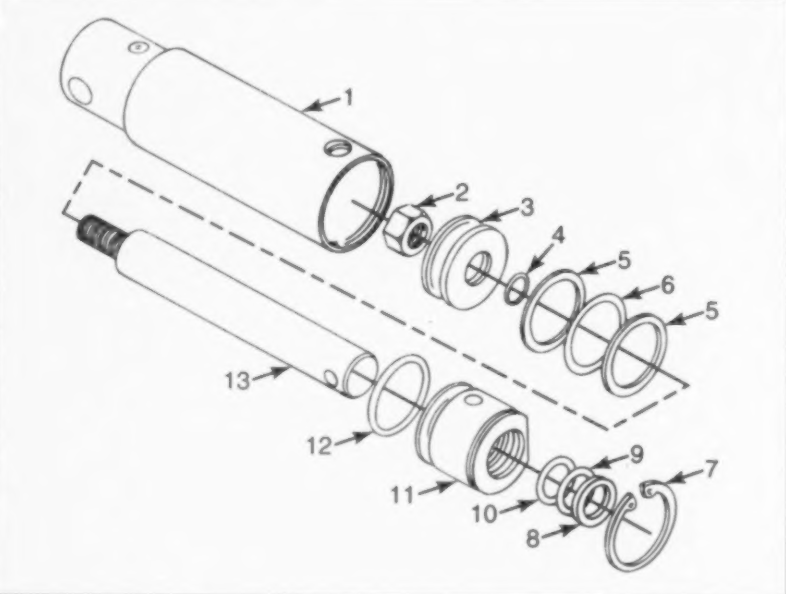
1. Acorn nut
2. Washer
3. Jam nut
4. Adjusting screw
5. Washer
6. Spring
7. Ball retainer
8. Ball
9. Seat
10. Valve body
11. Spool
12. O-rings
13. Washer
14. Centering spring
15. Cup
16. Washer
17. Screw
18. End cap

Figure 5: Hydraulic-lift cylinder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1. Cylinder tube
2. Nut
3. Piston
4. O-ring
5. Back-up rings
6. O-ring
7. Snap ring
8. Seal
9. Back-up ring
10. O-ring
11. Rod guide
12. O-ring
13. Rod

Figure 4 and Figure 5 reproduced by permission of Textron Turf Care and Specialty Products, Racine, Wisconsin.

Assignment Sheet 1

5. The flow diagram in Figure 6 on the next page is for a Sundstrand hydrostatic transmission.

   a. What type of oil is represented by the solid-black coloring of the piping?

      Oil type — ______________________________

   b. Which pump provides oil from the reservoir to the low-pressure portion of the system?

      Pump — ______________________________

   c. What type of pump is used for the main system pump?

      Pump type — ______________________________

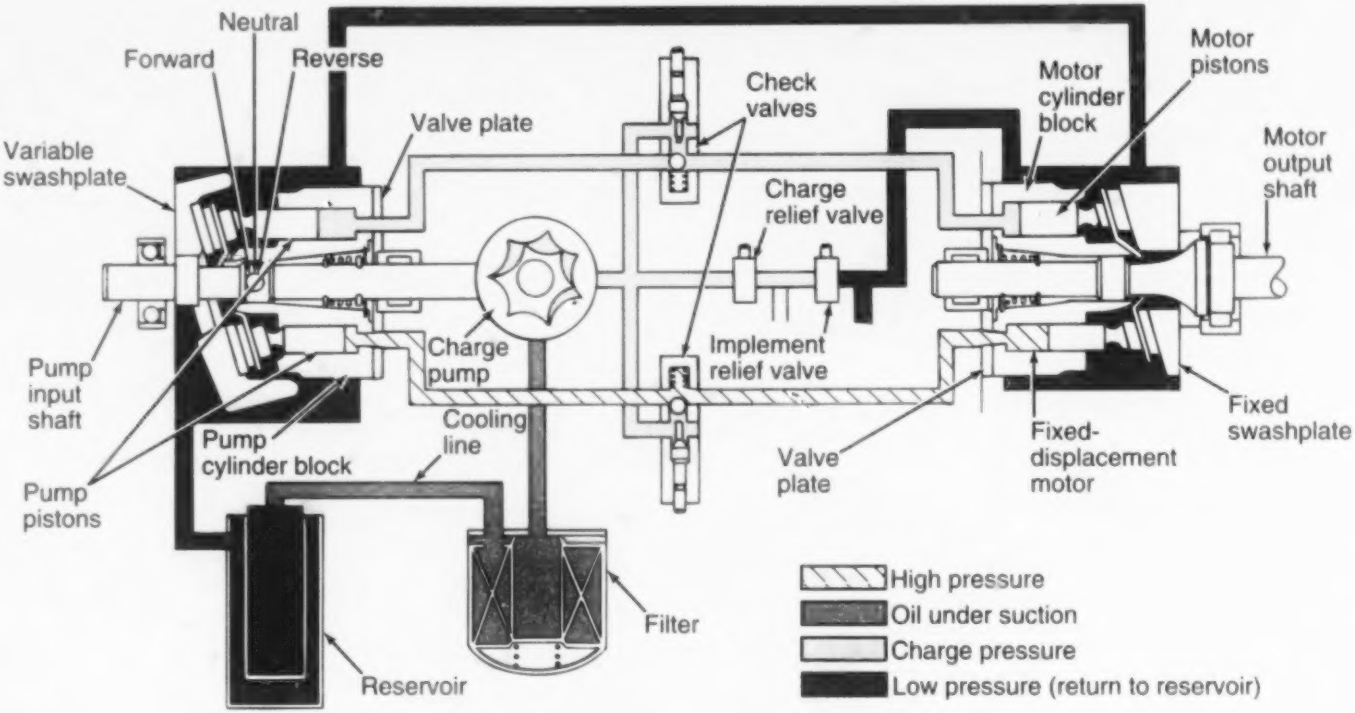
   d. What type of pump is used for the charge pump?

      Pump type — ______________________________

   e. Is the fluid filtered just after it leaves the reservoir or just before it returns to the reservoir? (Circle the correct answer below.)

      Just after Just before

Figure 6: Sundstrand piston-to-piston hydrostatic-transmission flow diagram


Neutral
Forward
Reverse
Valve plate
Check valves
Motor cylinder block
Motor pistons
Variable swashplate
Charge relief valve
Motor output shaft
Charge pump
Implement relief valve
Pump input shaft
Cooling line
Fixed swashplate
Pump cylinder block
Valve plate
Fixed-displacement motor
Pump pistons
Filter
Reservoir
▨ High pressure
▩ Oil under suction
☐ Charge pressure
■ Low pressure (return to reservoir)

Principles of Fluid Power
Unit 3

Job Sheet 1—Measure Hydraulic-System Temperature

Introduction

This job sheet covers the measurement of temperature in a hydraulic system. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include gaining direct access to the hydraulic fluid and using a thermometer to determine the fluid temperature. In some systems, pressure and temperature may be reported on gauges.

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.
2. Watch your instructor's demonstration of measuring hydraulic-system temperature and any supporting media provided by your instructor.
3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one hydraulic system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.
4. Ask your instructor to provide you with power product equipment that uses a hydraulic system.
5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.
6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.
7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 1

Worksheet—Measure Hydraulic-System Temperature

Name ______________________ Attempt number ________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 1

Worksheet—Measure Hydraulic-System Temperature

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Principles of Fluid Power
Unit 3

Job Sheet 2—Measure Hydraulic-System Pressure

Introduction

This job sheet covers the procedures associated with measuring hydraulic-system pressure. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include gaining access to the system fluid and using a gauge to measure the pressure.

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.
2. Watch your instructor's demonstration of measuring hydraulic-system pressure and any supporting media provided by your instructor.
3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one hydraulic system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.
4. Ask your instructor to provide you with power product equipment that uses a hydraulic system.
5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.
6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.
7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 2

Worksheet—Measure Hydraulic-System Pressure

Name Attempt number

Date

Part A: Pre-performance check

Job

- Complete the following information concerning the assigned equipment.

  Equipment brand

  Equipment model/type and code

- Complete the following service-manual information.

  Service-manual title

  Section/page number of procedure

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature

Job Sheet 2

Worksheet—Measure Hydraulic-System Pressure

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Principles of Fluid Power
Unit 3

Job Sheet 3—Measure Hydraulic-System Flow

Introduction

This job sheet covers the procedures associated with measuring hydraulic-system flow. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include gaining access to the system lines and using special equipment such as a gauge to measure system flow.

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of measuring hydraulic-system flow and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one hydraulic drive system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a hydraulic drive system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 3

Worksheet—Measure Hydraulic-System Flow

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 3

Worksheet—Measure Hydraulic-System Flow

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	_______
Procedures completed correctly.	_______
Proper tools used correctly.	_______
Safety precautions observed.	_______
Service meets specifications.	_______
Clean-up and follow-up actions adequate.	_______
Overall rating	_______

Evaluator's comments ____

____

____

Principles of Fluid Power
Unit 3

Job Sheet 4—Measure Air Pressure

Introduction

This job sheet covers the procedures associated with measuring air pressure. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Check a pressure gauge
- Install a pressure gauge
- Operate and read a tire gauge
- Test a relief valve

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.
2. Watch your instructor's demonstration of measuring air pressure and any supporting media provided by your instructor.
3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one pneumatic system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.
4. Ask your instructor to provide you with power product equipment that uses a pneumatic system.
5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.
6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.
7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 4

Worksheet—Measure Air Pressure

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 4

Worksheet—Measure Air Pressure

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Principles of Fluid Power
Unit 3

Job Sheet 5—Measure Airflow

Introduction This job sheet covers the procedures associated with measuring airflow. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. The specific procedures will depend on the equipment design and airflow meter used.

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of measuring airflow and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that produces airflow.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 5

Worksheet—Measure Airflow

Name ______________________________ Attempt number __________

Date ______________________________

Part A: **Pre-performance check**

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 5

Worksheet—Measure Airflow

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	
Procedures completed correctly.	
Proper tools used correctly.	
Safety precautions observed.	
Service meets specifications.	
Clean-up and follow-up actions adequate.	
Overall rating	

Evaluator's comments

Hydraulic and Pneumatic Drive Systems
Unit 4

Objective Sheet

Unit objective

After completing this unit, the student should be able to describe the design and operation of hydraulic and pneumatic drive systems and perform routine maintenance and service procedures on such systems. The student should demonstrate these competencies by completing the assignment sheet and job sheets and by scoring a minimum of 85 percent on the written test.

Specific objectives

After completing this unit, the student should be able to

1. Distinguish between descriptions of the types of clutches used with hydraulic and pneumatic drive systems.
2. Distinguish between descriptions of the types of hydraulic drive trains used in power product equipment.
3. State the functions of the major components of hydrostatic drive trains.
4. Complete statements about the principles of operation of hydrostatic drive trains.
5. Complete statements about the principles of operation of axial-piston hydraulic pumps.
6. Complete statements about the principles of operation of radial-piston hydraulic pumps.
7. Label types of hydrostatic drive trains as classified by their pump and motor designs.
8. Complete statements about the principles of operation of hydraulic equipment drives.
9. List typical service procedures required for hydraulic drive systems.
10. Describe the types of pneumatic power used to accomplish work in power product equipment.
11. State the functions of the major components of pneumatic drive systems.
12. Complete statements about the principles of operation of pneumatic equipment drives.
13. List typical service procedures required for pneumatic drive systems.
14. Determine hydraulic and pneumatic drive-system service specifications and parts requirements. (Assignment Sheet 1)
15. Perform routine maintenance on hydraulic drive trains. (Job Sheet 1)
16. Repair hydraulic drive trains. (Job Sheet 2)
17. Perform routine maintenance on hydraulic equipment drives. (Job Sheet 3)

Objective Sheet

18. Repair hydraulic equipment drives. (Job Sheet 4)
19. Perform routine maintenance on pneumatic equipment drives. (Job Sheet 5)
20. Repair pneumatic equipment drives. (Job Sheet 6)

Hydraulic and Pneumatic Drive Systems
Unit 4

Information Sheet

1. **Types of clutches used with hydraulic and pneumatic drive systems and their descriptions**

Note: Clutches are used in drive trains and equipment drives to control the transmission of power between the engine and the drive system. There are several reasons the flow of power must be controlled. A primary reason for controlling power is to allow the engine to run without applying power to a drive system, as when braking to a stop. Another reason for controlling power is to allow the reconfiguration of the drive system, as when changing drive speeds or direction. With power applied, reconfiguring the drive system may be very difficult for the operator to accomplish or may cause equipment damage due to the substantial forces involved.

- **Mechanical clutch**—Input power is disengaged from the drive system so that speed or directional changes can be made

  Note: Mechanical clutches are the most common type of clutch used—even for hydraulic and pneumatic drive systems. The use of mechanical clutches is common because of the use of mechanical methods for transferring power from the engine to the transmission or transaxle. For the operator to change speeds or to shift from forward to reverse, the engine clutch is usually disengaged so that power is not applied to the drive train. Once the drive has been reconfigured, the clutch is re-engaged to allow power to be applied to the drive.

- **Valve clutch**—Valves within the system are used to redirect pressure flow or change the amount of pressure without removing input power

  Note: Valve clutches are used in automatic transmissions and other hydraulic or pneumatic systems to reconfigure power flow in the system or to place the drive system in neutral.

2. **Types of hydraulic drive trains used in power product equipment and their descriptions**

Note: Both types of hydraulic drive trains may be configured with either a transmission or transaxle.

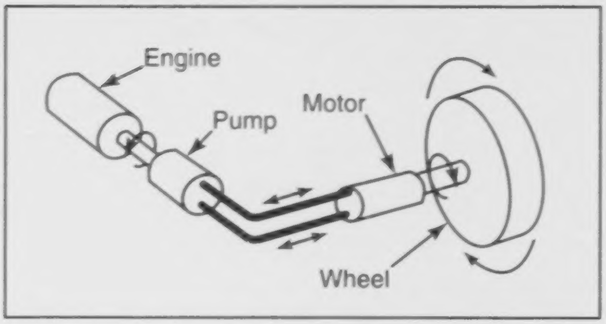
- **Automatic drive train**—Hydraulic drive train in which changes in the load and vehicle speed control the positioning of valves, clutch pistons, and bands to produce gear shifts with no operator action other than throttle control

  Note: True automatic transmissions like those found on automobiles are seldom used on power product equipment; however, improvements in hydrostatic technology are closing the differences between automatic and hydrostatic designs.

- **Hydrostatic drive train**—Hydraulic drive train in which the engine drives a hydraulic pump, which in turn transmits power to a hydraulic motor that drives the wheels; gear changes are normally accomplished by the operator's positioning an actuator in a desired position

  Note: The term *hydrostatic* refers to the use of a hydraulic pump and a hydraulic motor as part of the drive train (see Figure 1 on the next page).

Figure 1: Operation of hydrostatic drive train

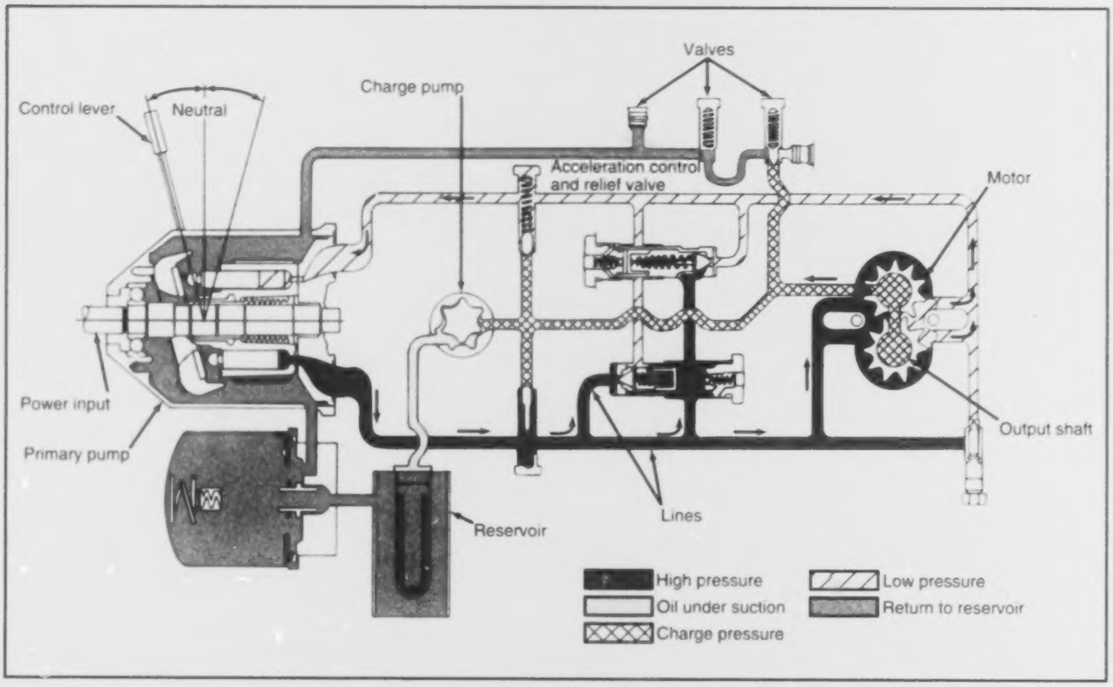

Engine
Pump
Motor
Wheel

3. **Major components of hydrostatic drive trains and their functions** (see Figure 2)

Note: The exact components of a hydrostatic drive train will vary according to a number of factors. Hydrostatic drive trains differ as a result of the type of pump used, whether the drive train is a transmission or transaxle, number of speeds, auxiliary hydraulic systems, and equipment application. In addition to the typical components shown in Figure 2, some systems have filters to remove contaminants from the fluid or cooling systems to reduce the heat that builds up as the fluid circulates through the system.

Because the more-common design of hydraulic drive trains is the hydrostatic design, it is the type illustrated in Figure 2. With the hydrostatic drive train, the rotational output of the engine drives a hydraulic pump that outputs rotary power to drive the final drive.

Figure 2: Major components of hydrostatic drive trains


Valves
Charge pump
Control lever
Neutral
Acceleration control and relief valve
Motor
Power input
Primary pump
Output shaft
Lines
Reservoir
High pressure
Low pressure
Oil under suction
Return to reservoir
Charge pressure

Information Sheet

- **Control lever**—Allows the operator to select drive-train settings

  Note: The control lever allows the operator to select a speed in multiple-speed drive trains, direction in units that have forward and reverse, and settings such as *neutral* and *park*. The lever controls whether fluid flows (*park* and *neutral* versus power transmission to the drive wheels), which direction it flows (forward and reverse), and the rate of flow (speed).

- **Power input**—Provides the power to operate the primary pump and, in some cases, a charge pump

  Note: Some hydrostatic systems have a charge pump or auxiliary pump that supplies fluid to the primary pump. Both pumps are usually driven by the equipment engine.

- **Reservoir**—Stores fluid for use in the system

- **Primary pump**—Converts input power to hydraulic pressure

  Note: The most-common primary-pump designs in hydrostatic drive trains are the axial- and radial-piston designs. In the axial-piston design, the piston bores are aligned parallel to the input shaft. In the radial-piston design, the piston bores are perpendicular to the input shaft.

- **Charge pump**—Moves the fluid from the reservoir to the primary pump

  Note: The charge pump is a low-pressure pump used to supply fluid to the main power pump of the hydraulic system.

- **Lines**—Carry the fluid through the system

- **Valves**—Control the fluid flow through the system

- **Motor**—Responds to system pressure to produce the power output

- **Output shaft**—Transmits power to the final-drive components

  Note: Typically, the output shaft connects to the differential in a transmission and to the drive axles in a transaxle, which uses an integrated differential.

4. **Principles of operation of hydrostatic drive trains** (see Figure 2 on page 158)

   Note: The hydrostatic drive train is the most commonly used hydraulic drive-train design for power product equipment. It is used on all-terrain vehicles, riding lawn mowers, garden tractors, and other types of equipment. There are variations in drive-train designs, but most of these variations center around (1) the type of pump used and (2) whether the drive train uses a transmission or a transaxle.

   - Rotary power from the engine drives a hydraulic pump.

   - In the simplest designs, a rotary pump, such as a gerotor design, pressurizes fluid in the system and the pressurized fluid produces rotation within a hydraulic motor.

Information Sheet

- In more-complex designs, variable-displacement pumps are used, which allow the control of fluid-flow volume.

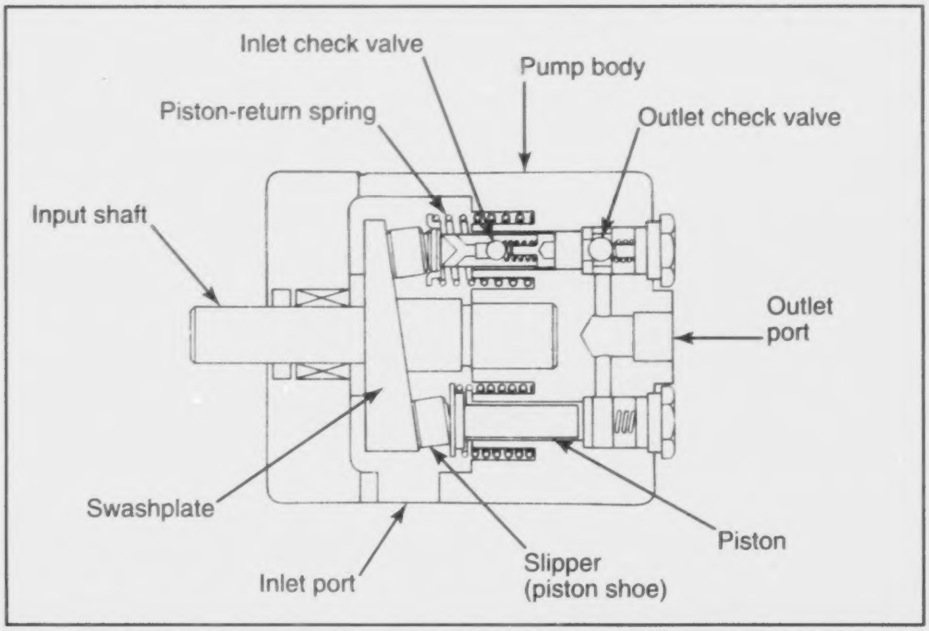
  Note: As you have learned, displacement pumps are those that work by moving a quantity of fluid to create a low-pressure area into which a similar quantity of fluid will flow. Some pumps are designed so that the amount of fluid displaced on any cycle can be varied, either through operator control or in response to factors such as load or engine speed. When displacement is low, the amount of power transmitted is low. To transmit more power, the amount of displacement is increased.

- The amount of displacement controls the volume of fluid flow so that the more flow allowed, the faster the motor operates.
- In some designs, the input shaft also drives a separate charge pump that is used to bring fluid from the reservoir into the active flow paths.
- The output of the hydraulic motor is either directed through a differential or is integrated into a transaxle to turn the drive axle.

5. Principles of operation of axial-piston hydraulic pumps (see Figure 3)

Note: The two common designs of primary pumps used in power product equipment are the axial-piston and the radial-piston designs. Both are variable-displacement pumps—that is, the rate at which fluid moves through the system can be varied by changing the amount of fluid pumped with each cycle. The term *axial piston* refers to the fact that the pistons are aligned parallel to the axis of the input shaft.

Figure 3: Major components of axial-piston hydraulic pumps



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Information Sheet

- A charge pump moves fluid from the reservoir to the pump pistons when they are retracted in their cylinders.

  Note: Most charge pumps are centrifugal or rotary designs. In some systems, no charge pump is used. Instead, the rotation of the swashplate pumps fluid into the primary pump pistons.

- The input shaft causes the swashplate to rotate.

  Note: The input shaft is turned by the equipment engine.

- The swashplate is set at an angle, with the base of each piston resting against the swashplate.

  Note: The base of the piston, called a *slipper* or *piston shoe,* is a pad connected to the piston with a swivel, so as the swashplate passes by each piston, the slipper maintains a flat surface on the swashplate.

- The rotation of the swashplate causes the pistons to move forward in their cylinders, which moves fluid to the motor.

- The incoming fluid pushes a piston back in its cylinder, which causes the swashplate to turn.

  Note: In short, the system behaves like a double-acting piston. When the pump piston pushes fluid through the system, it acts on the piston in the motor and pushes against the swashplate to make it turn.

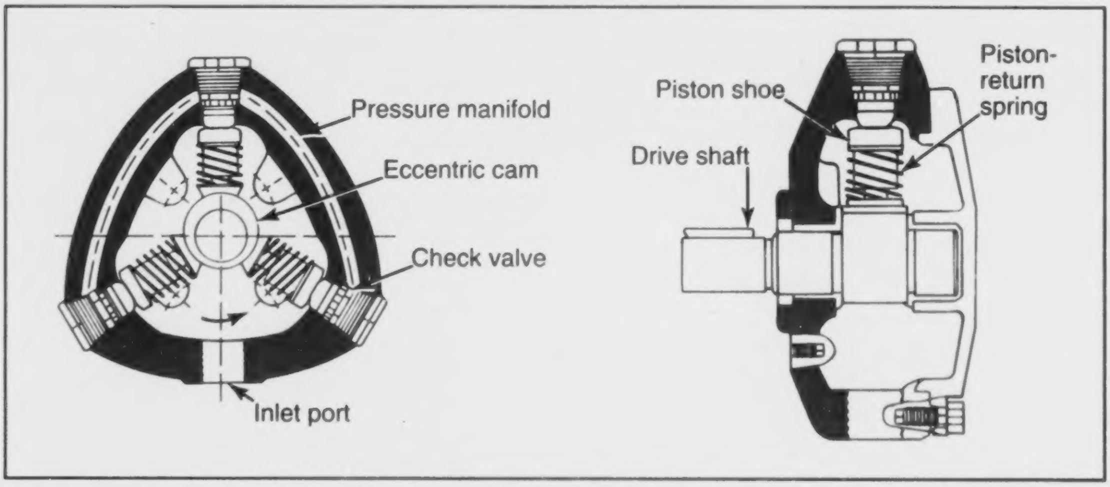
- The turning swashplate causes the output shaft to rotate.

- As the tilt of the motor swashplate pushes the piston forward in its cylinder, fluid is forced into the return lines, which carry fluid back to the reservoir.

6. **Principles of operation of radial-piston hydraulic pumps** (see Figure 4)

   Note: The term *radial piston* refers to the fact that the pistons are aligned perpendicular to the axis of the input shaft, so that they radiate out from it.

Figure 4: Major components of radial-piston hydraulic pumps



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Information Sheet

- A charge pump moves fluid from the reservoir to the pump.

  Note: In some systems, the charge pump functions only to start the system or to change the flow direction. Otherwise, the system is full of fluid and continues to circulate that fluid. In other designs, fluid temperature and pressure open or close valves as necessary to route the flow of the fluid.

- Fluid entering the pump flows into a cylinder as it rotates past the inlet port.

  Note: Ball-piston pumps generally have five or seven pistons. The odd number of pistons prevents the pressures in the pump from becoming too balanced.

- The ball piston squeezes fluid through the outlet port as it passes that port.

- As fluid flows into the motor, it enters cylinders and pushes past the ball pistons, creating a rotational force.

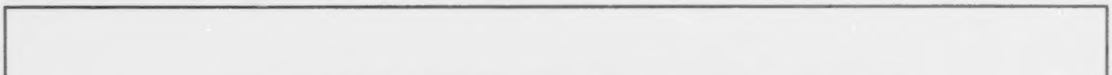
- Fluid flows through the motor and into a return line that takes the fluid back to the pump or to the reservoir, depending on pressure levels.

7. Types of hydrostatic drive trains as classified by their pump and motor designs

Note: Hydrostatic transmissions and transaxles consist of a system that includes a hydraulic pump that drives a hydraulic motor. One way of describing these systems is by stating the type of pump and the type of motor used in a drive train.

- **Axial piston to axial piston** (see Figure 5)

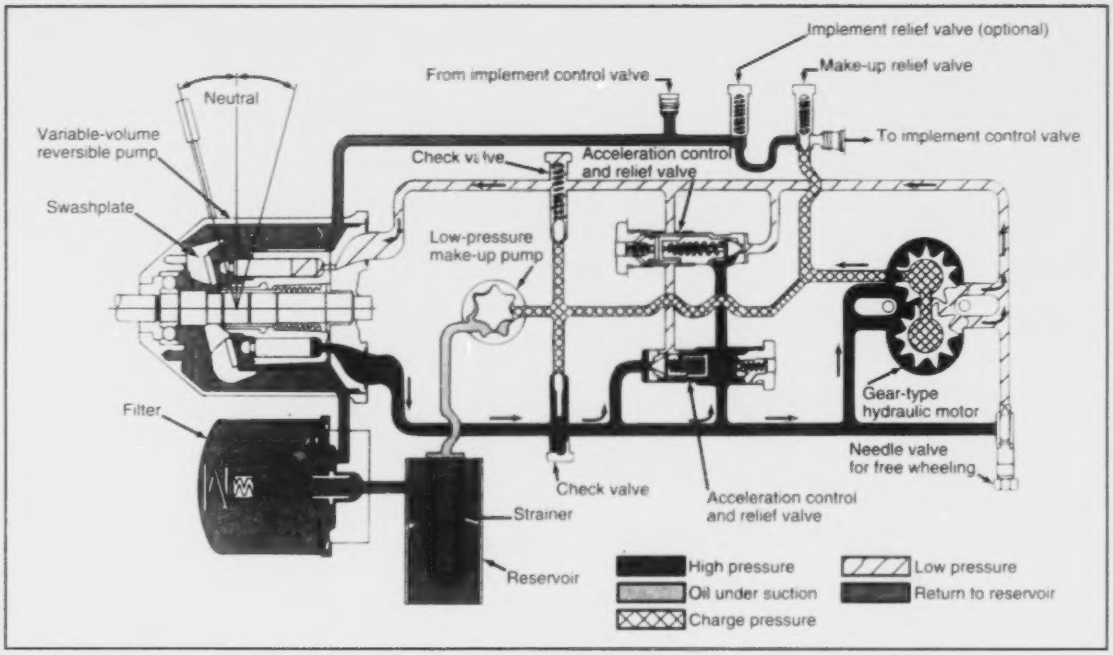
Figure 5: Axial-piston-to-axial-piston drive train


Neutral
Forward
Reverse
Valve plate
Variable swashplate
Check valves
Charge relief valve
Motor cylinder block
Motor pistons
Motor output shaft
Pump input shaft
Charge pump
Implement relief valve
Pump pistons
Pump cylinder block
Cooling line
Valve plate
Fixed-displacement motor
Fixed swashplate
Filter
Reservoir
▨ High pressure
■ Oil under suction
☐ Charge pressure
■ Low pressure (return to reservoir)

Information Sheet

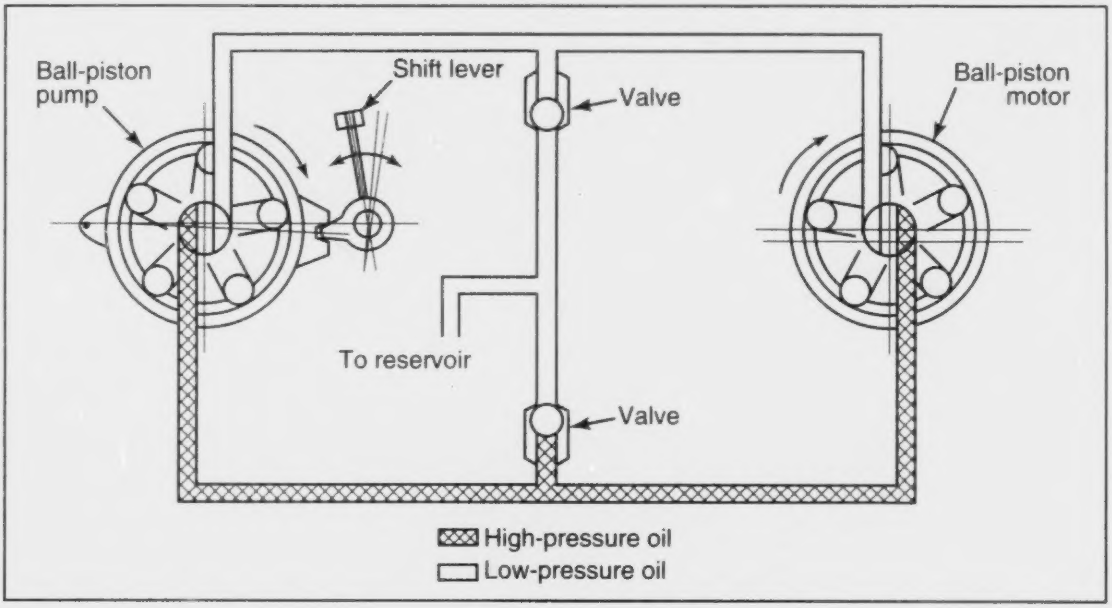
- **Axial piston to gear** (see Figure 6)

Figure 6: Axial-piston-to-gear drive train


Implement relief valve (optional)
From implement control valve
Make-up relief valve
Neutral
Variable-volume reversible pump
To implement control valve
Check valve
Acceleration control and relief valve
Swashplate
Low-pressure make-up pump
Filter
Gear-type hydraulic motor
Needle valve for free wheeling
Check valve
Acceleration control and relief valve
Strainer
Reservoir
High pressure
Low pressure
Oil under suction
Return to reservoir
Charge pressure

- **Radial piston to radial piston** (see Figure 7)

Figure 7: Radial-piston-to-radial-piston drive train


Ball-piston pump
Shift lever
Valve
Ball-piston motor
To reservoir
Valve
High-pressure oil
Low-pressure oil

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Information Sheet

8. Principles of operation of hydraulic equipment drives

Note: There are generally two types of hydraulic equipment drives. In the first type, mechanical force from the engine is used to power the equipment's hydraulic motor, much like a hydrostatic drive train. In the second type, power from a hydraulic system on the equipment, such as a lift system, is diverted to the equipment drive by a hose or line. The first type is more common and is described here.

- The engine output is used to drive a pump.
- The pump pressurizes hydraulic fluid to produce a source of power.
- The hydraulic power is transmitted through a system of pistons and valves to apply force to the equipment.

9. Typical service procedures required for hydraulic drive systems

- Check fluid level
- Inspect seals
- Service input-drive components
- Service output-drive components
- Replace filters
- Change fluid
- Overhaul hydraulic components
- Adjust system components
- Remove and replace transmission or transaxle

10. Types of pneumatic power used to accomplish work in power product equipment and their descriptions

Note: Air is used in two ways in the drive systems of power product equipment: (1) moving air is used to accomplish work by transferring power in much the same way that hydraulic fluid is used in drive trains and equipment drives; (2) differences in air pressure are used to accomplish work. Both methods are also used in combination.

- **Moving air**—Equipment uses moving air to exert pressure against a mechanism or object to accomplish work

  Note: Moving air can cause objects to move, such as when leaves are driven by a blower. Air is made to move in two primary ways in power product equipment. (1) Air pumps—generally propellers or impellers—move air. (2) Air is compressed into a smaller space to increase its pressure so that releasing air from the tank creates a stream of moving air. Both of these methods are used to drive equipment.

Information Sheet

- **Pressure differential**—Equipment uses areas of high or low pressure to accomplish work

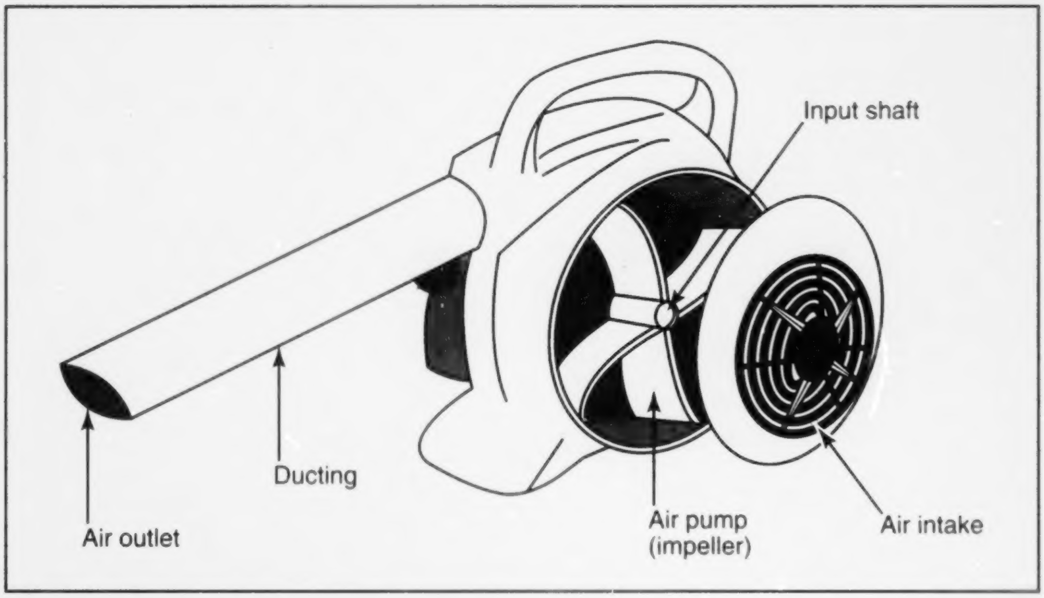
  Note: Air pressure at sea level is normally 14.7 pounds per square inch. Because air tries to maintain equal pressure in a system, air moves from areas of high pressure to areas of low pressure. You have seen this principle at work in diaphragm pumps, such as those used for fuel pumps. This same principle can be used to drive equipment.

  There are very few applications of pneumatic force in power product equipment drive trains, other than in ultra-light aircraft. Equipment-drive applications, however, are quite common. In some cases, compressed air is used to power lift systems or pneumatic tools or to create high-pressure areas in pressure-differential systems. More often, moving air is used to move objects, such as raising grass to be cut and discharging it, lifting snow and discharging it, or moving leaves with a blower.

11. **Major components of pneumatic drive systems and their functions** (see Figure 8)

Note: The components of pneumatic drive systems vary greatly with the design and application and whether the system uses an air pump, compressed air, or pressure differential to transfer force. Components also vary in closed versus open pneumatic drive systems. Closed systems are those that use trapped air, such as compressed air in a tank. Open systems are those that pull air into the system and force it out, such as a leaf blower. The system shown in Figure 8 represents the major components of an open system. Closed systems are covered in more detail in *Power Product Equipment Technician: Construction Equipment*, Unit 2, "Water Pumps and Air Compressors."

Figure 8: Major components of pneumatic drive systems



- **Air intake**—Allows air to enter the system

  Note: In an open system, air is normally taken in from the atmosphere. Depending on the use of the air, the equipment may have filters or other devices that clean the air or regulate its temperature.

- **Air pump**—Brings air into the system

  Note: Numerous types of air pumps are used. The blade of a rotary lawn mower is an air pump because it pulls air in under the mower, creates a low-pressure area under the mower deck, and forces air out the discharge chute. Propellers, impellers, and blower fans are also air pumps. Air compressors are pumps that use pistons to pull air into the system and to compress it in much the same way that the engine compresses the fuel/air mixture for combustion. The engine itself can be an air pump; it uses the internal-combustion process to create a pumping action through changes in pressure.

- **Ducting**—Routes air to the desired location

  Note: *Ducting* is a generic term for a network of tubes, chambers, valves, cylinders, and other components that may be used to direct air from one location to another. In power product equipment, ducting may be formed by the shape of the equipment, as with the deck of a lawn mower, or it may serve little other purpose than to conduct air from one location to another, such as the discharge tube of a leaf blower. The ducting may also be shaped in such a way as to control the flow of the air, its speed, direction, or pressure. In the case of a compressed-air system, the ducting network includes a reservoir in which air is stored under pressure.

- **Output**—Applies air to the work to be done

  Note: The air may be used to move objects external to the equipment, objects passing through the equipment, or components of the equipment. In the case of an ultra-light aircraft, the output is the flow of air over the wings of the airplane created by the propeller (air pump). The air foil of the wings causes the air passing over the top of the wing to go farther and, thus, faster, creating a low-pressure area over the wing. This results in a lift force under the wings. The output may be air pressure pushing a diaphragm or air pushing grass through a mower.

- **Air outlet**—Allows air to exit the system

  Note: In most pneumatic systems, the air is allowed to escape back into the atmosphere. This is obvious in a system such as the discharge from a lawn mower. It is also true in a compressed-air system in which the air is released from the reservoir to do work and then vented to the atmosphere. Even most closed systems have relief valves or other means of releasing air from the system.

12. Principles of operation of pneumatic equipment drives

Note: The engine is sometimes used to drive an air compressor that provides a source of pressurized air for pneumatic equipment. In other cases, a diaphragm system is connected to an equipment drive, producing power much like a fuel pump. However, the common source of pneumatic force in power product equipment is that described below.

- The engine drives the blade or impeller of an air pump.
- The rotation of the impeller creates a low-pressure area on the back side of the impeller blades, causing air to move into the air pump through an inlet.
- The continued rotation of the impeller blades pushes air ahead of the blades.

Information Sheet

- An opening in the air-pump body allows the air to escape.

  Note: The outlet of the pump body is often smaller than the inlet, so the air is accelerated to increase its force.

- The air is directed to the location where work is to be done.

13. Typical service procedures required for pneumatic drive systems

- Check airflow or pressure
- Inspect seals
- Service input-drive components
- Service output-drive components
- Replace filters
- Balance impeller
- Overhaul pneumatic components
- Adjust system components
- Remove and replace air pump

Hydraulic and Pneumatic Drive Systems
Unit 4

Assignment Sheet 1—Determine Hydraulic and Pneumatic Drive-System Service Specifications and Parts Requirements

Name ______________________________ Date ______________

Evaluation criteria	**Rating**
Directions have been followed.	_______
Minimum of 85 percent of answers are correct.	_______

Note: Each correct answer is worth 5 points.

Overall rating _______

Evaluator's comments ______________________________

____

____

Introduction Pneumatic and hydraulic drive systems have many applications in power product equipment. Hydraulic and hydrostatic drive systems tend to be more expensive and complicated than mechanical drive systems. However, hydraulic and hydrostatic drive systems provide smoother shifting, more-compact packaging without clutches and gears, lower service requirements, and other characteristics that appeal to consumers. For these reasons, their use is growing more popular, and the power product equipment technician must know how to provide service for the types of power product equipment that use hydraulic drive systems. Pneumatic systems also provide many conveniences that are popular with consumers. This popularity presents many service opportunities, including the overhaul of pumps, replacement of components, etc. In this assignment sheet, you will practice selecting parts and determining specifications for hydraulic and pneumatic drive systems that you are likely to service in your career as a power product equipment technician.

Exercise

Directions Using the resources available in your facility, determine the part numbers and specifications requested in the following questions. Write your answers on the blanks provided under each question, or follow the specific directions with the question.

Assignment Sheet 1

Part A: Questions 1 through 5 apply to an Eaton Model 6 hydrostatic transmission used on numerous models of self-propelled equipment, including International Harvester Model 382H and MTD Model 764A. The unit is illustrated in Figure 1 on the opposite page.

1. What type of pump-motor system is used in this unit? (Circle the correct answer below.)

   Axial piston to axial piston

   Axial piston to gear

   Radial piston to radial piston

2. Can the piston balls be interchanged among the cylinders? (Circle the correct answer below.)

   Yes No

3. To remove the control shaft (Item 38), it is necessary to drill a hole through the aluminum housing. What diameter of hole is required?

   Diameter required — ____________________

4. What type of adhesive/sealant is recommended to seal the outer edge of the oil seals (Items 6, 28, and 39)?

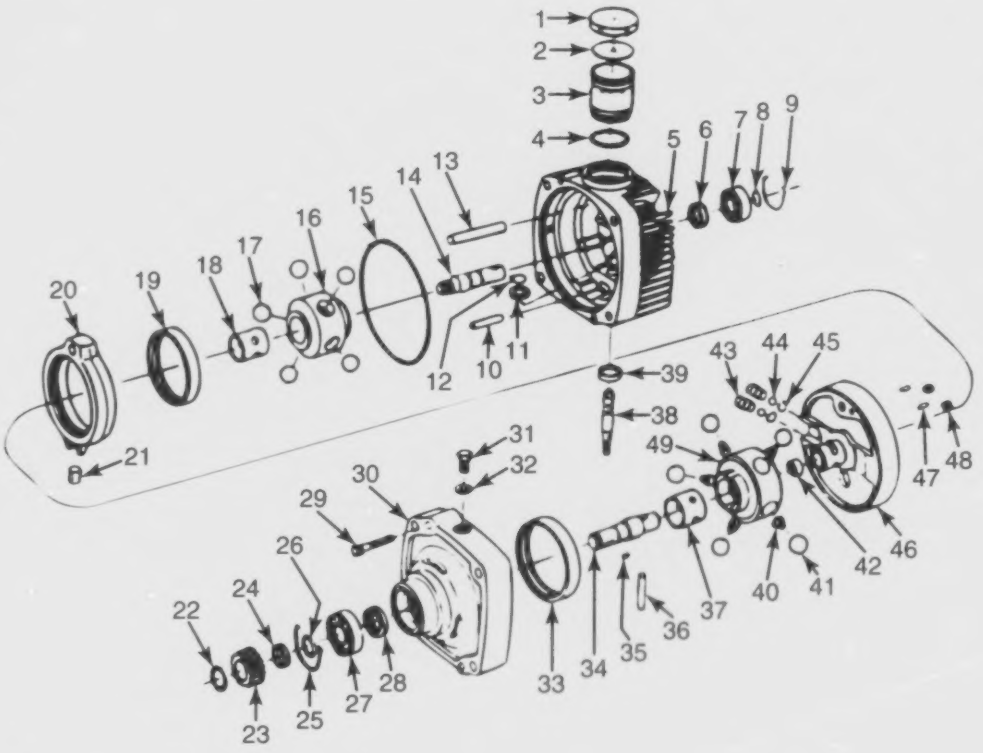
   Adhesive/sealant — ____________________

5. The unit body is held together by cap screws. What is the recommended torque?

   Torque — ____________________

Assignment Sheet 1

Figure 1: Eaton Model 6 hydrostatic transmission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1. Cover
2. Gasket
3. Reservoir
4. Gasket
5. Housing
6. Oil seal
7. Ball bearing
8. Snap ring
9. Retainer
10. Dowel pin
11. Washer
12. Snap ring
13. Cam pivot pin
14. Input shaft
15. O-ring
16. Pump rotor
17. Pump ball pistons
18. Rotor bushing
19. Pump race
20. Pump cam ring
21. Insert
22. Snap ring
23. Output gear
24. Spacer
25. Retainer
26. Snap ring
27. Ball bearing
28. Oil seal
29. Cap screw
30. Body
31. Venting plug
32. Gasket
33. Motor race
34. Output shaft
35. Key
36. Drive pin
37. Rotor bushing
38. Control shaft
39. Oil seal
40. Springs
41. Motor ball pistons
42. Needle bearing
43. Directional check-valve body
44. Check-valve ball
45. Snap ring
46. Pintle
47. Roll pin
48. Plug
49. Motor rotor

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Assignment Sheet 1

Part B: Questions 6 through 10 apply to a Sundstrand Series 15 hydrostatic transmission used on equipment such as International Harvester Models 1250, 1450, and 1650, as shown in Figure 2 on the opposite page.

6. What type of pump-motor system is used in this unit? (Circle the correct answer below.)

   Axial piston to axial piston

   Axial piston to gear

   Radial piston to radial piston

7. What is the distinguishing marking between the pump valve plate (18) and the motor valve plate (36)?

   Distinguishing marking — ______________________________

8. When tightening the cap screws that hold the center section to the housing, what torque value should be used?

   Torque value — ______________________________

9. If new bearings are installed for Item 35, how should they be seated in the center housing?

   ____

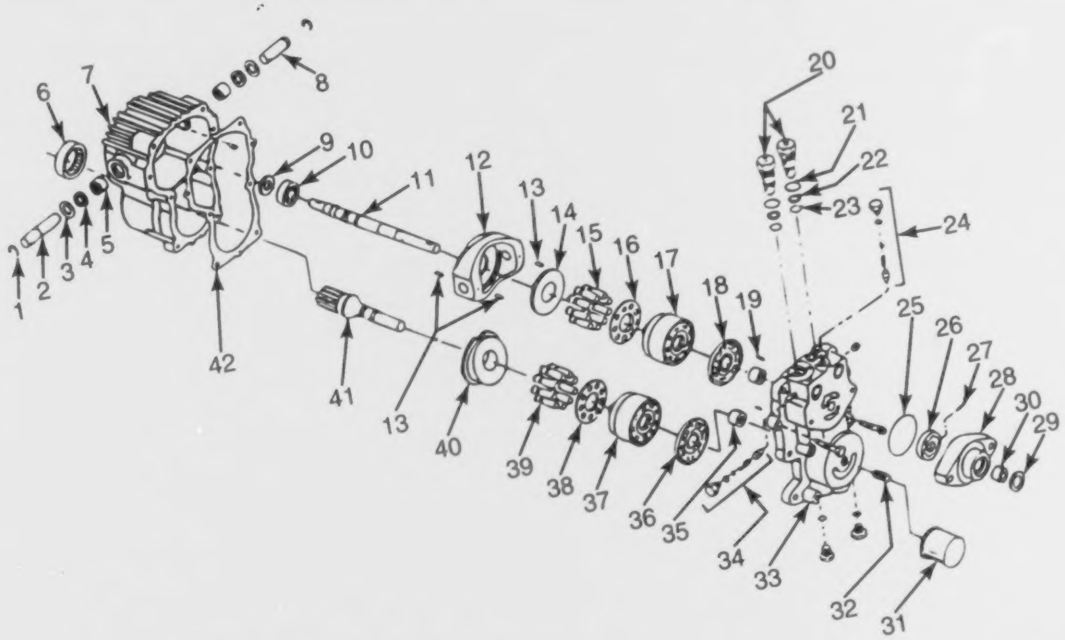
   ____

   ____

10. What is the fluid capacity of the transmission and differential?

    Fluid capacity — ______________________________

Figure 2: Sundstrand Series 15 hydrostatic transmission



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1. Retaining ring (2)
2. Control shaft
3. Washer (2)
4. Seal (2)
5. Bearing (2)
6. Bearing
7. Housing
8. Trunnion shaft
9. Seal
10. Bearing
11. Pump shaft
12. Swashplate (pump)
13. Spring pins
14. Thrust plater
15. Pump pistons
16. Slipper retainer
17. Cylinder block (pump)
18. Valve plate
19. Dowel pin (2)
20. Check valves
21. Back-up washer
22. O-ring
23. O-ring
24. Implement-lift relief valve
25. O-ring
26. Rotor assembly
27. Drive pin
28. Charge-pump housing
29. Seal
30. Bearing
31. Oil filter
32. Filter fitting
33. Center section
34. Charge relief valve
35. Bearing (2)
36. Valve plate
37. Cylinder block (motor)
38. Slipper retainer
39. Motor pistons
40. Swashplate (motor)
41. Motor shaft
42. Gasket

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Assignment Sheet 1

Part C: Questions 11 through 15 apply to a Vickers T-66 hydrostatic transmission as used on Simplicity garden tractors such as Models 3415H and 3416H. This hydrostatic transmission is illustrated in Figure 3 on the opposite page.

11. What type of pump-motor system is used in this unit? (Circle the correct answer below.)

    Axial piston to axial piston

    Axial piston to gear

    Radial piston to radial piston

12. What type of charge pump does this system use?

    Charge pump — ______________________________

13. What is the allowable piston-shoe thickness tolerance among the nine pistons?

    Thickness tolerance — __________________________

14. What is the recommended fluid for this unit?

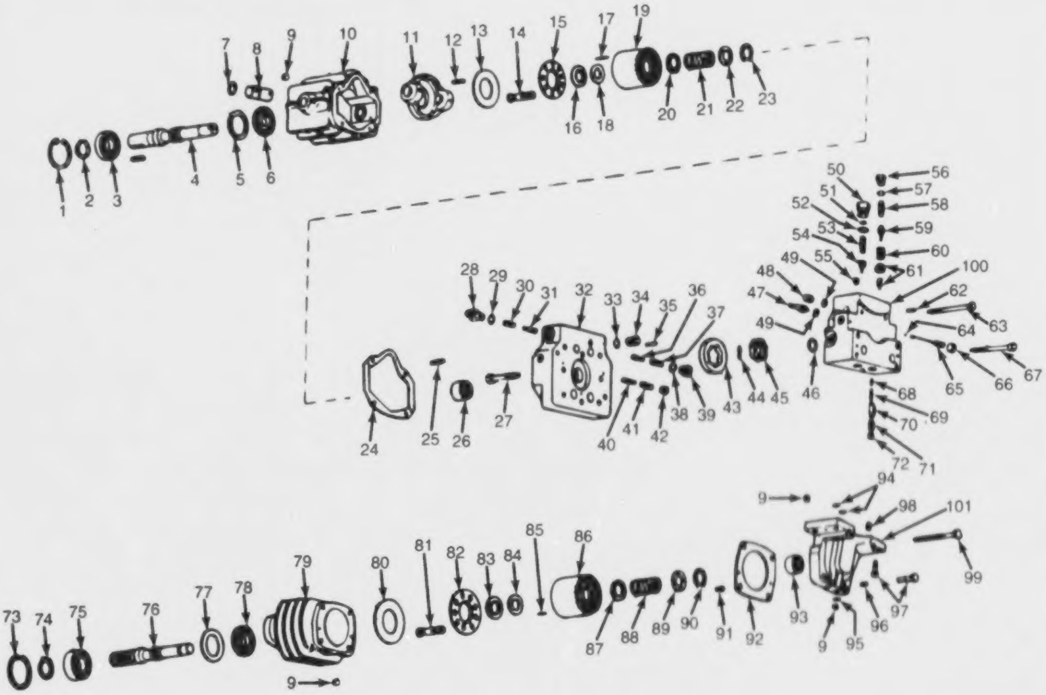
    Fluid — ___________________________________

15. The hydrostatic control lever should be in what position when the fluid reservoir is filled?

    Lever position — ______________________________

Assignment Sheet 1

Figure 3: Vickers hydrostatic transmission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1. Snap ring
2. Snap ring
3. Bearing
4. Pump shaft
5. Spacer
6. Seal
7. O-ring
8. Pintle (2 used)
9. Plug
10. Pump housing
11. Yoke
12. Pin (2 used)
13. Swashplate
14. Piston (9 used)
15. Shoe plate
16. Spherical washer
17. Pin (3 used)
18. Washer
19. Cylinder
20. Thrust washer
21. Spring
22. Lift limiter
23. Snap ring
24. Gasket
25. Pin (2 used)
26. Bearing
27. Screw (2)
28. Connector
29. O-ring
30. Spring
31. Charge-pump relief valve
32. Valve plate
33. O-ring
34. Plug
35. Pin (2)
36. Implement relief valve
37. Spring
38. O-ring
39. Plug
40. Check valve (2 used)
41. Spring (2)
42. Plug (2)
43. Outer rotor
44. Key
45. Inner rotor
46. O-ring (2)
47. Plunger
48. Plug
49. O-rings
50. Plug
51. O-ring
52. Shim
53. Spring
54. High-pressure relief valve
55. Plug
56. Cap
57. O-ring
58. Spring
59. Pin
60. Spring
61. Soft-ride valve & seat
62. Pin
63. Cap screws (2)
64. Ball
65. Spring
66. Plug
67. Allen-head cap screw (2)
68. Pin (2)
69. Spring (2)
70. High-pressure check valve (2 used)
71. Guide (2)
72. Plug (2)
73. Snap ring
74. Snap ring
75. Bearing
76. Motor shaft
77. Spacer
78. Seal
79. Motor housing
80. Swashplate
81. Pistons (9 used)
82. Shoe plate
83. Spherical washer
84. Washer
85. Pin (3 used)
86. Cylinder
87. Thrust washer
88. Spring
89. Lift limiter
90. Snap ring
91. Pin (2)
92. Gasket
93. Bearing
94. O-rings
95. O-rings
96. Pin (2)
97. Cap screw (6)
98. Pin (2)
99. Cap screw (2)
100. Transfer block
101. Valve plate

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Assignment Sheet 1

Part D: Questions 16 through 20 apply to a Sundstrand Hypogear hydrostatic transmission used on Wheel Horse tractors up to mid-1973. See the illustration in Figure 4 on the opposite page.

16. What type of pump-motor system is used in this unit? (Circle the correct answer below.)

    Axial piston to axial piston

    Axial piston to gear

    Radial piston to radial piston

17. What is the maximum variance allowed in the thickness of the nine piston slippers (bronze caps crimped to the ends of the pistons)?

    Maximum variance — ____________________

18. How often should the transmission oil and filter be changed?

    ____

19. When tightening the plugs for the check valves (Item 28), what torque value should be used?

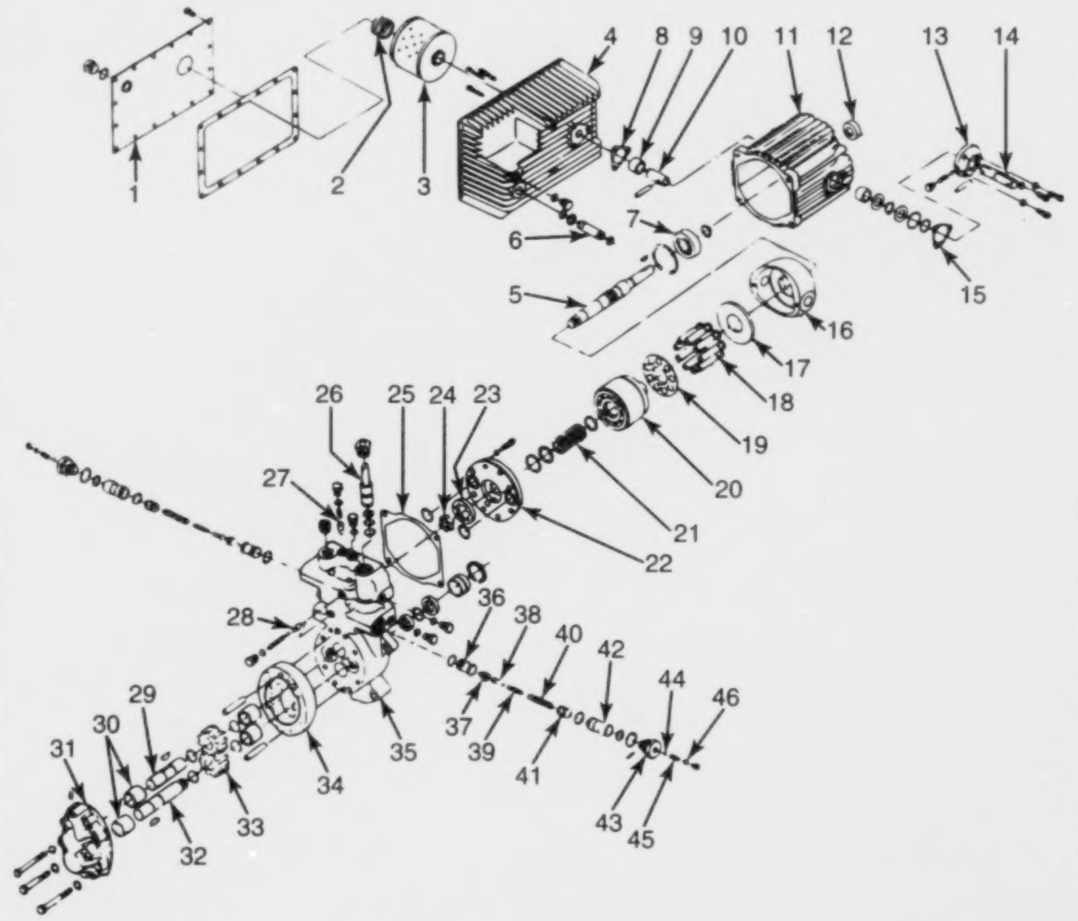
    Torque value — ____________________

20. What is the maximum turning torque of the pump shaft if the unit is properly shimmed?

    Turning torque — ____________________

Assignment Sheet 1

Figure 4: Sundstrand Hypogear hydrostatic transmission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1. Cover
2. Filter spring
3. Filter
4. Reservoir
5. Pump shaft
6. Suction tube
7. Ball bearing
8. Gasket
9. Needle bearing
10. Stub shaft
11. Pump housing
12. Oil seal
13. Neutral detent plate
14. Control shaft
15. Shim
16. Swashplate
17. Thrust plate
18. Pistons (9)
19. Slipper retainer
20. Pump cylinder block
21. Spring
22. Valve plate
23. Driven rotor
24. Driving rotor
25. Shim gasket
26. Drive/no-drive valve
27. Charge relief valve
28. Check valve (2)
29. Motor idler shaft
30. Bearing
31. End cap
32. Motor output shaft
33. Gear set
34. Spacer plate
35. Center section
36. Seat
37. Cone
38. Spring guide
39. Spring (inner)
40. Spring (outer)
41. Piston
42. Sleeve
43. Metering plug
44. Ball
45. Spring
46. Spring seat

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Hydraulic and Pneumatic Drive Systems
Unit 4

Job Sheet 1—Perform Routine Maintenance on Hydraulic Drive Trains

Introduction

This job sheet covers the routine maintenance associated with hydraulic drive trains. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect hydraulic drive-train components
- Lubricate gears, chains, and linkages
- Adjust belt tension
- Align pulleys and shafts
- Check fluid level
- Change fluid and filters

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of performing routine maintenance on hydraulic drive trains and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one hydraulic drive train. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a hydraulic drive train.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 1

Worksheet—Perform Routine Maintenance on Hydraulic Drive Trains

Name ______________________ Attempt number ________

Date ______________________

Part A: **Pre-performance check**

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 1

Worksheet—Perform Routine Maintenance on Hydraulic Drive Trains

---

Part B: Performance evaluation

Evaluation criteria **Rating**

Correct procedures identified for assigned equipment. ________

Procedures completed correctly. ________

Proper tools used correctly. ________

Safety precautions observed. ________

Service meets specifications. ________

Clean-up and follow-up actions adequate. ________

Overall rating ________

Evaluator's comments ____

____

____

Hydraulic and Pneumatic Drive Systems
Unit 4

Job Sheet 2—Repair Hydraulic Drive Trains

Introduction

This job sheet covers the repair procedures associated with hydraulic drive trains. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace hydraulic drive-train components, including pumps, hoses, valves, etc.
- Overhaul mechanical drive-train subsystems, including actuators and input and output drives
- Perform adjustments to return equipment to original specifications

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of repairing hydraulic drive trains and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one hydraulic drive train. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a hydraulic drive train.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/ materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 2

Worksheet—Repair Hydraulic Drive Trains

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 2

Worksheet—Repair Hydraulic Drive Trains

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

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Hydraulic and Pneumatic Drive Systems
Unit 4

Job Sheet 3—Perform Routine Maintenance on Hydraulic Equipment Drives

Introduction

This job sheet covers the routine maintenance associated with hydraulic equipment drives. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect equipment-drive components
- Lubricate gears, chains, and U-joints
- Adjust belt tension
- Align pulleys and shafts
- Check for hydraulic leaks
- Check system pressures

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of performing routine maintenance on hydraulic equipment drives and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one hydraulic equipment drive. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a hydraulic equipment drive.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 3

Worksheet—Perform Routine Maintenance on Hydraulic Equipment Drives

Name ______________________________ Attempt number ________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 3

Worksheet—Perform Routine Maintenance on Hydraulic Equipment Drives

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Part B: Performance evaluation

Evaluation criteria	Rating
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

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Hydraulic and Pneumatic Drive Systems
Unit 4

Job Sheet 4—Repair Hydraulic Equipment Drives

Introduction

This job sheet covers the repair procedures associated with hydraulic equipment drives. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace hydraulic equipment-drive components, including connectors, hoses, reservoirs, etc.
- Overhaul hydraulic equipment-drive subsystems, including valves and cylinders

  Note: Sometimes it is not cost-effective to complete an overhaul of the equipment-drive systems. Check with your instructor to help you evaluate the cost-effectiveness of overhauling the system you are assigned.

- Perform adjustments to return equipment to original specifications

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of repairing hydraulic equipment drives and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one hydraulic equipment drive. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a hydraulic equipment drive.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 4

Worksheet—Repair Hydraulic Equipment Drives

Name ______________________ Attempt number ________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 4

Worksheet—Repair Hydraulic Equipment Drives

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ______________________________

____

____

Hydraulic and Pneumatic Drive Systems
Unit 4

Job Sheet 5—Perform Routine Maintenance on Pneumatic Equipment Drives

Introduction

This job sheet covers the routine maintenance associated with pneumatic equipment drives. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect equipment-drive components
- Check for pneumatic leaks
- Check system pressures

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of performing routine maintenance on pneumatic equipment drives and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one pneumatic equipment drive. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a pneumatic equipment drive.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 5

Worksheet—Perform Routine Maintenance on Pneumatic Equipment Drives

Name ______________________ Attempt number ________

Date ______________________

Part A: **Pre-performance check**

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 5

Worksheet—Perform Routine Maintenance on Pneumatic Equipment Drives

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Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ______________________________

____

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Hydraulic and Pneumatic Drive Systems
Unit 4

Job Sheet 6—Repair Pneumatic Equipment Drives

Introduction This job sheet covers the repair procedures associated with pneumatic equipment drives. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace pneumatic equipment-drive components, including connectors, hoses, reservoirs, etc.
- Overhaul pneumatic equipment-drive subsystems, including valves and compression systems
- Perform adjustments to return equipment to original specifications

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of repairing pneumatic equipment drives and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one pneumatic equipment drive. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a pneumatic equipment drive.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 6

Worksheet—Repair Pneumatic Equipment Drives

Name ______________________ Attempt number ________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 6

Worksheet—Repair Pneumatic Equipment Drives

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Wheel and Brake Systems
Unit 5

Objective Sheet

Unit objective

After completing this unit, the student should be able to describe types of wheels and the operation of brake systems used on power product equipment and be able to perform routine maintenance and service procedures on such systems. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific objectives

After completing this unit, the student should be able to

1. State the functions of the major components of tire and wheel assemblies.
2. Match types of tires used in power product equipment to their correct descriptions.
3. List types of rims used in tire and wheel assemblies.
4. List types of wheel supports used in tire and wheel assemblies.
5. List typical service procedures required for tire and wheel assemblies.
6. Match specialty tools used in tire and wheel service to their correct uses.
7. State safety rules for performing tire and wheel service.
8. State definitions of the types of brake systems used in power product equipment.
9. Match the major components of mechanical brake systems to their correct functions.
10. Match types of mechanical brake systems to their correct descriptions.
11. Complete statements about the principles of operation of mechanical brake systems.
12. List typical service procedures required for mechanical brake systems.
13. Match the major components of hydraulic brake systems to their correct functions.
14. Complete statements about the principles of operation of hydraulic brake systems.
15. Distinguish among descriptions of types of disc- and drum-brake hydraulic-cylinder designs.
16. List typical service procedures required for hydraulic brake systems.
17. State safety rules for performing brake-system repair.
18. Label types of parking brakes used in power product equipment.

Objective Sheet

19. List typical service procedures required for parking brakes.
20. Determine tire-and-wheel-system service specifications and parts requirements. (Assignment Sheet 1)
21. Determine brake-system service specifications and parts requirements. (Assignment Sheet 2)
22. Service tires and rims. (Job Sheet 1)
23. Service wheel bearings and bushings. (Job Sheet 2)
24. Perform routine maintenance on mechanical brakes. (Job Sheet 3)
25. Repair mechanical brakes. (Job Sheet 4)
26. Perform routine maintenance on hydraulic brakes. (Job Sheet 5)
27. Repair hydraulic brakes. (Job Sheet 6)
28. Perform routine maintenance on parking brakes. (Job Sheet 7)
29. Repair parking brakes. (Job Sheet 8)

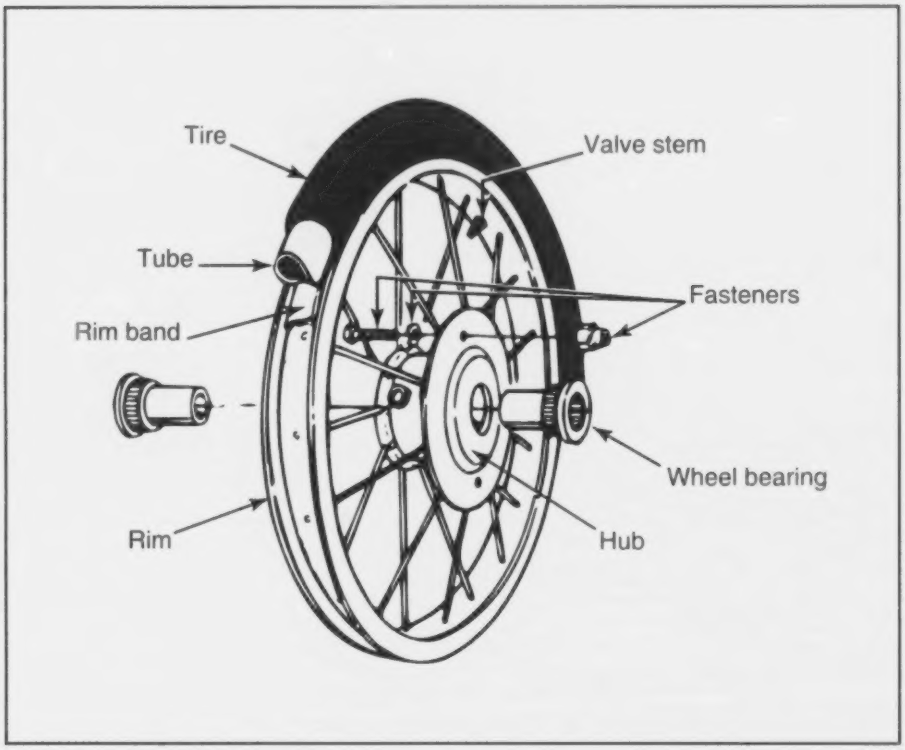
Wheel and Brake Systems
Unit 5

Information Sheet

1. **Major components of tire and wheel assemblies and their functions** (see Figure 1)

Note: The exact components of tire and wheel assemblies vary greatly due to the type of tire, the type of wheel, the application (drive wheel versus steering wheel), type of equipment (operator-guided equipment versus operator-ridden equipment), equipment costs, and other factors. The tire and wheel shown in Figure 1 is a pneumatic tire on a spoked rim—one of the applications for operator-ridden equipment.

Figure 1: Major components of tire and wheel assemblies



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- **Tire**—Supports the equipment and provides traction for self-propelled equipment
- **Tube**—Holds air under pressure

  Note: A tube is a rubber bladder that is filled with air. Objective 2 describes the types of tires used in power product equipment. One type of tire is filled with air and is called a *pneumatic tire*. Some pneumatic tires use tubes to hold the air that inflates the tire.

- **Valve stem**—Provides the means for inserting air into the tube or tire

Information Sheet

- **Rim**—Supports the tire and provides a seal for tubeless pneumatic tires

  Note: Objective 3 discusses the types of rims commonly used with power product equipment.

  Note: Some tire and wheel assemblies will also have a rim band, which is used with spoked wheels to provide a cushion between the rim and the tube to protect the tube from the spoke ends (see Figure 1).

- **Hub**—Provides the mechanism for mounting the tire and wheel assembly to the axle

  Note: Hubs may be solid or hollow. Solid hubs fit flush against a rotor mounted to the end of the axle. Hollow hubs provide a hole through which the axle extends (see Figure 1). Wheel hubs may house bearings to decrease the friction of the turning wheel (see Figure 1).

- **Fasteners**—Fasten the tire and wheel assembly to the axle

  Note: There are several ways of fastening tire and wheel assemblies to their axles. The axle may have threaded studs over which the rim slides to be secured with nuts called *lug nuts*. In other installations, fasteners called *lug bolts* go through the rim and thread into the axle. Some designs have a bolt or nut that installs onto the axle and holds the tire and wheel assembly on the axle. Many types of light power product equipment simply use a pin through the axle or a clip on the end of it to hold the tire and wheel assembly in place.

2. Types of tires used in power product equipment and their descriptions

- **Solid** (see Figure 2-a on the next page)—Tire that is usually made of solid rubber or hard plastic and, when mounted, seats completely on the wheel

  Note: Solid tires are routinely used on push mowers and similar small-wheeled equipment. Solid tires provide little in the way of cushioning the ride of the equipment over rough surfaces, but they are lightweight, durable, and relatively inexpensive.

- **Pneumatic** (see Figure 2-b on the next page)—Tire that is filled with air through a valve stem and, when mounted, seats along the wheel rim

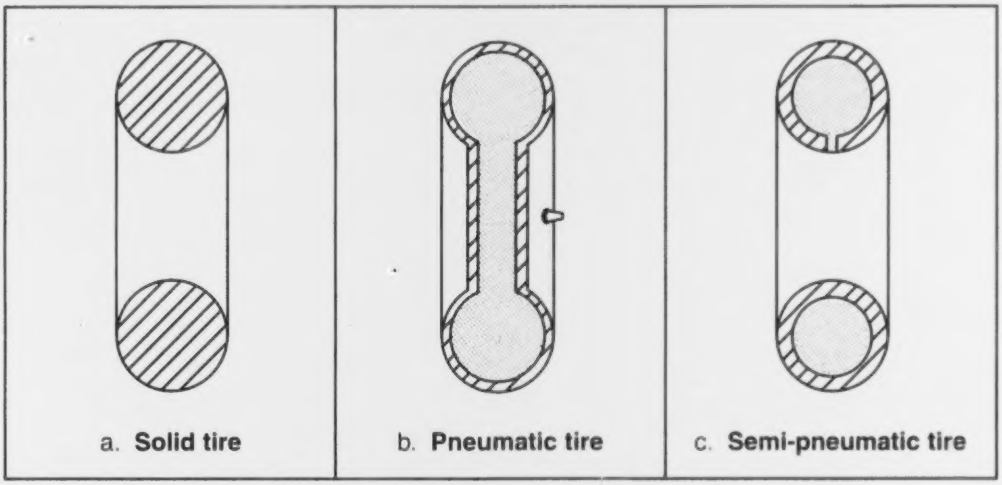
  Note: A pneumatic tire may use a rubber bladder called an *inner tube* or *tube* to hold the air, or the air may be put directly into the space between the tire and the rim. These tires are called *tube* and *tubeless* respectively. Compressed air is forced into the tire through a pneumatic valve generally called a *valve stem*. These tires soften the irregularities of the work surface and are the types commonly used on automobiles. In power product equipment applications, pneumatic tires are most often used on operator-ridden equipment and heavier operator-guided equipment, especially equipment used on rough or hard surfaces.

- **Semi-pneumatic** (see Figure 2-c on the next page)—Tire that is filled with air and vented to the outside atmosphere but has no valve stem and, when mounted, seats completely on the wheel

  Note: Semi-pneumatic tires are a compromise between pneumatic and solid tires. They provide a smoother ride, but they are not capable of carrying heavy loads that would push the air from the tire. Semi-pneumatic tires are used for some heavier guided equipment with over-sized rear wheels, such as tillers and push mowers.

Information Sheet

Figure 2: Types of tires



a. **Solid tire** b. **Pneumatic tire** c. **Semi-pneumatic tire**

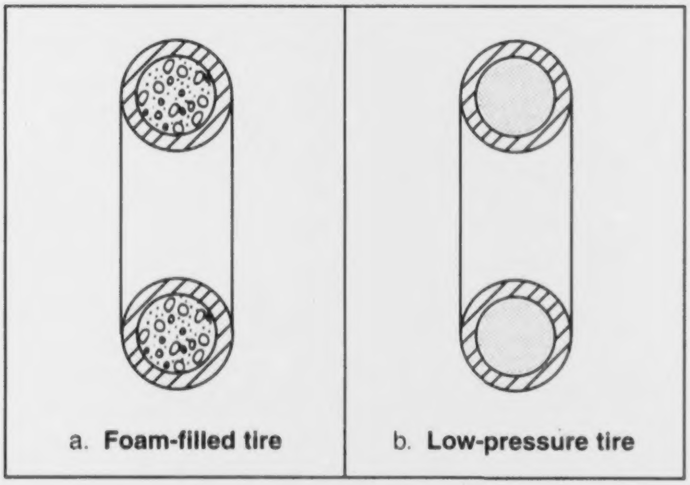
- **Foam filled** (see Figure 3-a)—Tire that is made of a hard-rubber outer covering with an inner core of softer rubber and, when mounted, seats completely on the wheel

  Note: Foam-filled tires provide cushioning almost equal to pneumatic tires but do not have air leaks or flats and, thus, require less maintenance. They are used on a variety of operator-ridden equipment, frequently as smaller front tires on equipment with pneumatic rear tires.

- **Low pressure**—Tire that has a thick outside and a small, hollow inside in which air is trapped and, when mounted, seats completely on the wheel

  Note: Low-pressure tires are constructed something like tubeless pneumatic tires; however, low-pressure tires do not have valve stems. Air is simply trapped in the hollow space when the tire is mounted to the rim. This approach can be used for almost any application but is generally used only as a low-cost substitute for pneumatic tires.

Figure 3: Types of tires (cont.)



a. **Foam-filled tire** b. **Low-pressure tire**

3. Types of rims used in tire and wheel assemblies

- **Split** (see Figure 4-a)

  Note: Split rims generally consist of two parts that fit together to hold a solid, semi-pneumatic, foam-filled, or low-pressure tire. The two halves form a channel in which the tire is held. The parts of a split rim are normally held together by the same fasteners that mount the wheel to the axle. Split rims are usually made of steel.

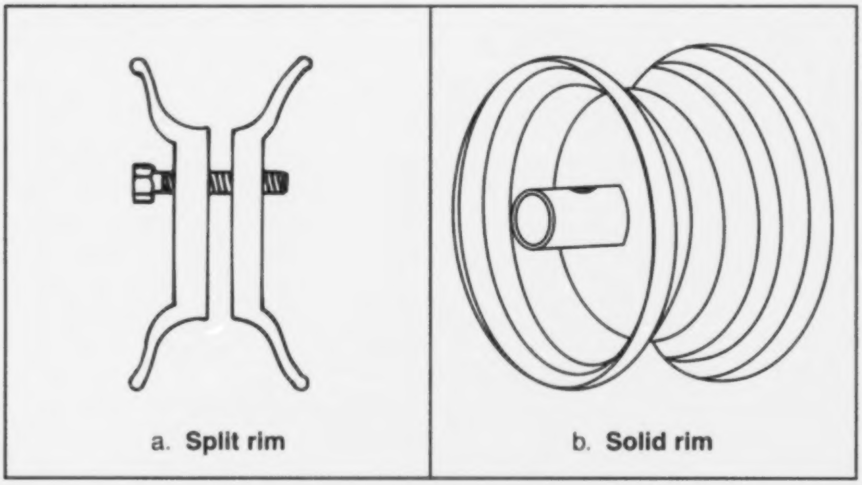
- **Solid** (see Figure 4-b)

  Note: Solid rims are most frequently used for solid and pneumatic tires, but they may be used for any type of tire. They are often made of plastic for solid tires used on lightweight applications. Rims for pneumatic tires and heavier applications are generally made of steel or aluminum. For pneumatic tires, the rim provides an opening for installation of the valve stem for tubeless tires or for the valve stem of a tube to pass through.

- **Spoked** (see Figure 1 on page 205)

  Note: A spoked rim is like that commonly found on bicycles. The spokes are metal wires or rods that connect the hub and rim. For power product equipment applications, spoked rims can be used with any type of tire, through the most common types are pneumatic. Many motorcycles use spoked rims as do some operator-guided equipment that may have spoked rims in the rear for improved stability and steering.

Figure 4: Types of rims



a. **Split rim**

b. **Solid rim**

4. Types of wheel supports used in tire and wheel assemblies

Note: The load of wheeled equipment rests on the tire and wheel assembly. This weight is likely to include not only the equipment body and engine but also the operator and loads such as grass cuttings. Additionally, the tire and wheel assemblies must support this load over rough terrain, which exaggerates the pressures and stresses exerted on the wheels. Consequently, most types of wheeled power product equipment include additional support at the point of contact between the wheel and the axle. Two common methods of providing this support are bearings and bushings.

Information Sheet

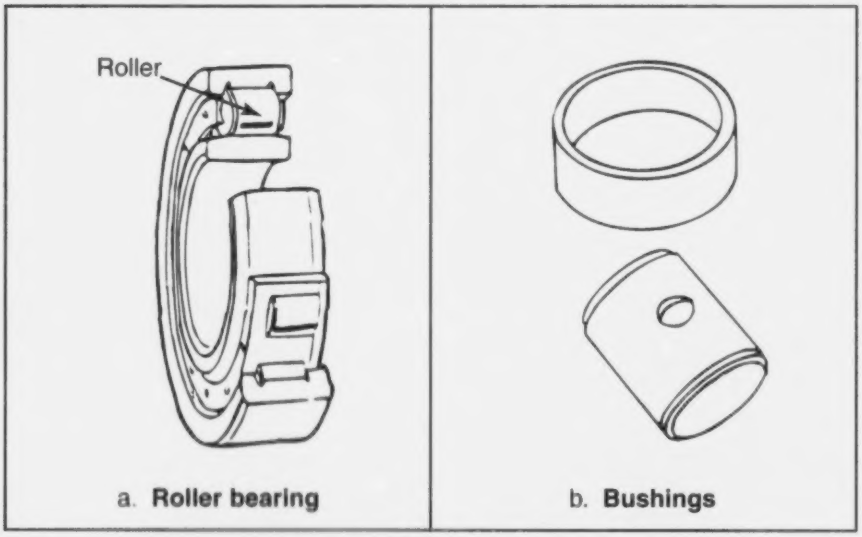
- **Bearings** (see Figure 5-a)

  Note: Bearings are used to support rotational loads. There are several types of bearings, but each works by turning with the load. Two common types of bearings used to support wheels in power product equipment are roller bearings (see Figure 5-a) and ball bearings. Both types are constructed with an inner and outer race that turn independently. As the names imply, round rods called *rollers* decrease the friction between the races of a roller bearing, while steel balls serve the same role in ball bearings. Bearings are lubricated and reduce the friction between the tire and wheel assembly and the axle.

- **Bushings** (see Figure 5-b)

  Note: Bushings support the tire and wheel assembly by spreading the weight of the supported load over a larger area and, in some cases, reducing friction by turning, though not at the same rate as the wheel. Most bushings used for wheel support in power product equipment are simply tubes or tubes with flanges called *shoulders*. While most are made of metal, some types of equipment use plastic or nylon bearings.

Figure 5: Types of wheel supports



a. **Roller bearing**

b. **Bushings**

5. Typical service procedures required for tire and wheel assemblies

Note: Tire and wheel service can vary from rather simple to somewhat complex procedures. Service for a push mower that uses solid tires on solid-plastic rims is likely to consist of no more than removing the existing tire and wheel assembly and replacing it with a new one. Pneumatic tires and spoked wheels are likely to require numerous other procedures.

- Remove and replace wheel assembly
- Remove and replace tire
- Repair inner tube

  Note: Tubes are normally repaired with an adhesive or heat-sealed patch.

- Repair tubeless tire

  Note: Tubeless tires are normally repaired with patches or with rubber plugs.

- Replace valve stem
- Lubricate wheel bearings or bushings
- Remove and replace wheel bearings or bushings

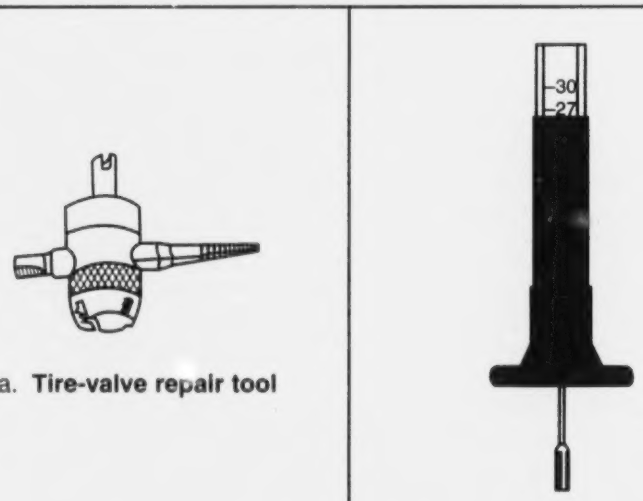
6. Specialty tools used in tire and wheel service and their uses

Note: As indicated in the note with the previous objective, service of pneumatic tires is generally more complex than the service of other types of tires; therefore, many of the tools shown in Figures 6 through 9 are used to service pneumatic tires.

- **Tire-valve repair tool** (see Figure 6-a)—Used to remove stems, repair stem threads, and extract broken cores
- **Tire-pressure gauge** (see Figure 6-b)—Used to measure air pressure in tubes and tires
- **Tire-tread-depth gauge** (see Figure 6-c)—Used to measure tire wear

Note: Tire tread is the variations in the surface of a tire that are designed to improve the tire's traction.

Figure 6: Specialty tools used in tire and wheel service



a. **Tire-valve repair tool**

c. **Tire-tread-depth gauge**

b. **Tire-pressure gauge**

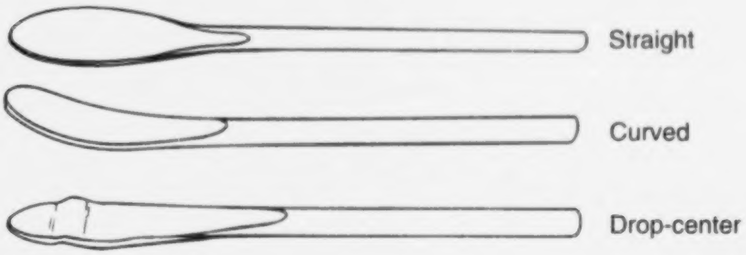
Information Sheet

- **Tire spoons** (see Figure 7-a)—Used to mount and demount tires

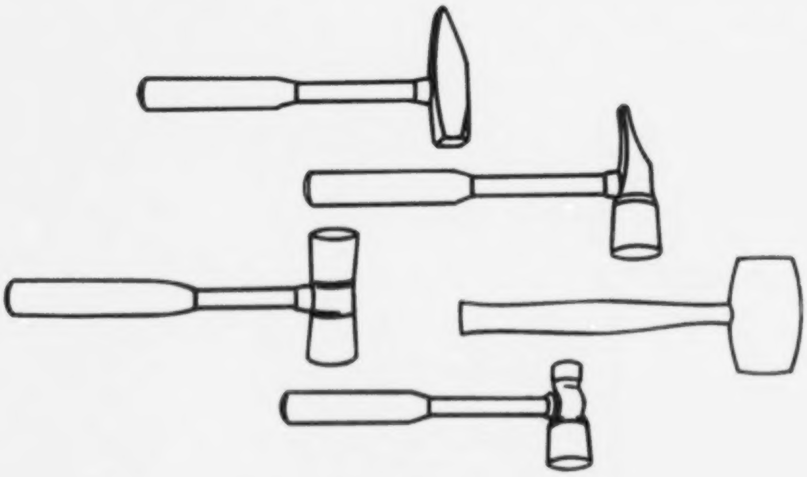
  Note: The term *mount* a tire means to install the tire on its rim; the term *demount* a tire means to remove a tire from its rim.

- **General-purpose hammers** (see Figure 7-b)—Used to separate tube and tubeless tires and other types of tires from rims and to separate wheels from axles

Figure 7: Specialty tools used in tire and wheel service (cont.)



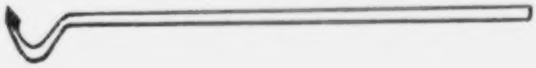
a. **Tire spoons**



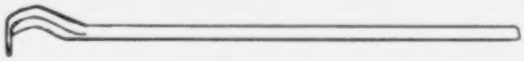
b. **General-purpose hammers**

- **Swan-neck bead tool** (see Figure 8-a)—Used to pry tires from rims
- **Bead breaker** (see Figure 8-b)—Used to break the seal between tubeless tires and rims
- **Portable bead breaker** (see Figure 8-c)—Used to apply pressure to the sidewall of a tire by clamping on the rim to separate the tire from the rim
- **Bead expander** (see Figure 8-d)—Used to apply pressure to the crown of a tire to improve the seal between the tire and the rim when mounting a tire

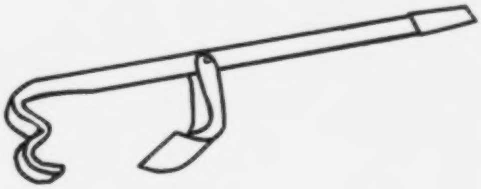
Figure 8: Specialty tools used in tire and wheel service (cont.)



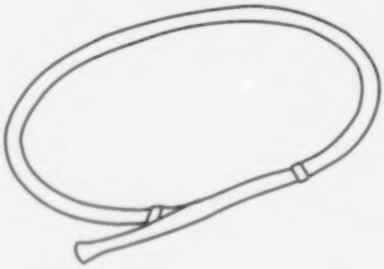
a. **Swan-neck bead tool**



b. **Bead breaker**



c. **Portable bead breaker**

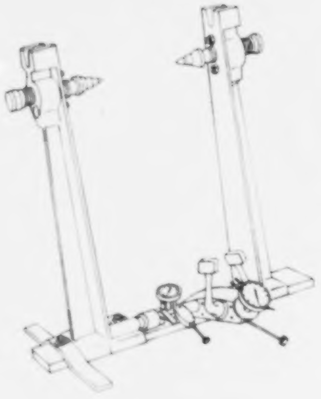


d. **Bead expander**

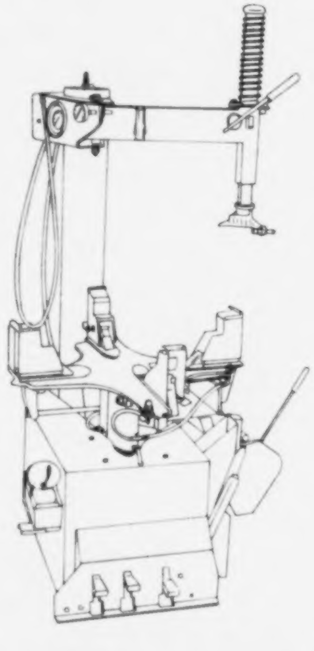
Information Sheet

- **Truing stand** (see Figure 9-a)—Used to return spoked rims to true alignment after spoke replacement
- **Tire-changing machine** (see Figure 9-b)—Used to remove tires from rims

Figure 9: Specialty tools used in tire and wheel service (cont.)



a. **Truing stand**



b. **Tire-changing machine**

7. Safety rules for performing tire and wheel service

Note: Pneumatic tires present special hazards due to the use of compressed air and the danger of blowouts when inflating or handling such tires. Another danger includes the need to provide a means of supporting the equipment while the normal support—the tire and wheel assembly—is being removed, serviced, and installed.

- **Never overinflate tires or tubes.**

  Note: Overinflating a tire or tube may cause the tire to explode either as the tire is being inflated or while it is in use. An exploding tire can throw debris or cause the operator to have an accident due to the surprise of the explosion.

- **Exhaust the air from tires before demounting.**

  Note: Working on a tire or tube that contains air also presents a danger of an explosion.

- **Do not apply heat to inflated tires or tubes.**

  Note: Heat causes air to expand, which is the same as overinflating the tire or tube.

- **Ensure that the vehicle cannot fall or roll when raised for service.**

  Note: Equipment must normally be raised or tilted up to remove wheels. Equipment can fall off a jack or fall from a raised position. Some types of power product equipment are heavy enough to cause death or serious injury if they should fall on the service technician.

- **Ensure that tire and rim sizes match.**

  Note: If a pneumatic tire is installed on a rim of the incorrect size, it is likely that the tire will not seal or will pinch the tube. If any other type of tire is installed on a rim of the wrong size, there is a good chance the tire will come off, which could lead to an operator's wrecking a self-propelled vehicle.

- **Do not attempt to repair damaged rims; replace them.**

  Note: Adequate repair of a rim by trying to bend it back to its proper shape or by welding it is generally impossible. A wheel assembly can break down if the rim is weak or deformed. However, some spoked-wheel systems do allow replacement of spokes. Once the spokes have been replaced, the rim may have to be returned to true alignment on a truing machine.

- **Before installing a tire, inspect it for damage and defects.**

- **Do not use tubes that are buckled, creased, or misshapened.**

  Note: Buckles and creases in tubes trap air or prevent the tube from filling completely, and they often lead to blowouts. A misshapened tube is an indication that there is a weakness in the tube, which means that the tire will not be properly inflated and that a blowout is more likely. Most low-speed tubes can be patched; however, tubes for high-speed applications such as motorcycles should not be repaired.

- **Ensure that the tube and the tire sizes match.**

  Note: Tubes and tires are manufactured in matching sizes. If the tube is too large for the tire, the tube will not be fully inflated when the tire is. This can lead to buckling or creases in the tube. If the tube is too small for the tire, the tire cannot be properly inflated.

- **Ensure that a tube is centered and properly seated in a tire before inflating the tube.**

  Note: The portion of the tire that mates with the rim is called the *bead*. The bead must make good contact with the rim in order to seal a tubeless tire and to ensure that tubes are not pinched between the rim and tire. Proper inflation of a tire requires that it make even contact around the rim as it is inflated.

- **Do not install a tube in a tubeless tire.**

- **Do not stand over a tire while inflating it.**

  Note: A tire or tube may explode while it is being inflated, or it may slip from the rim. Either of these situations can cause serious injury if a technician stands over the tire. Always stand to one side of a tire as you inflate it.

8. Types of brake systems used in power product equipment and their definitions

Note: A brake is a device used to stop or slow equipment motion by removing power or by applying enough force to overcome the power from the engine. Many types of self-propelled power product equipment are likely to have more than one brake. Brakes are sometimes used with equipment drives to stop equipment. For example, walk-behind rotary mowers built after June 30, 1982, are equipped with a control handle that must be engaged for the blade to turn and the blade must stop within 3 seconds once the handle is released. These brakes are covered in Unit 7, while this unit concentrates on brake systems used to stop the motion of a moving vehicle and to hold it. These functions are performed by the service-brake system, though some types of equipment also have a parking-brake system designed specifically to hold the vehicle. There are three principal types of service brakes as described here, while parking brakes are discussed in Objective 18.

- **Mechanical**—Brake system that uses mechanical means to allow the operator to apply pressure to the wheels to slow or stop equipment movement

  Note: All wheel brake systems have mechanical components; however, some systems are purely mechanical.

- **Hydraulic**—Brake system that uses special hydraulic fluid in a closed system to assist in the application of pressure to the wheels to slow or stop equipment movement

  Note: Hydraulic-brake systems are used primarily on large motorcycles and other types of power product equipment capable of moving heavy loads or moving at high speeds. Hydraulic brakes are similar to those found on automobiles. Such systems have a hydraulic and a mechanical portion. The hydraulic portion is designed to allow the operator to produce maximum braking power with minimal effort.

- **Engine braking**—Brake system that uses torque from the engine to slow or stop equipment movement

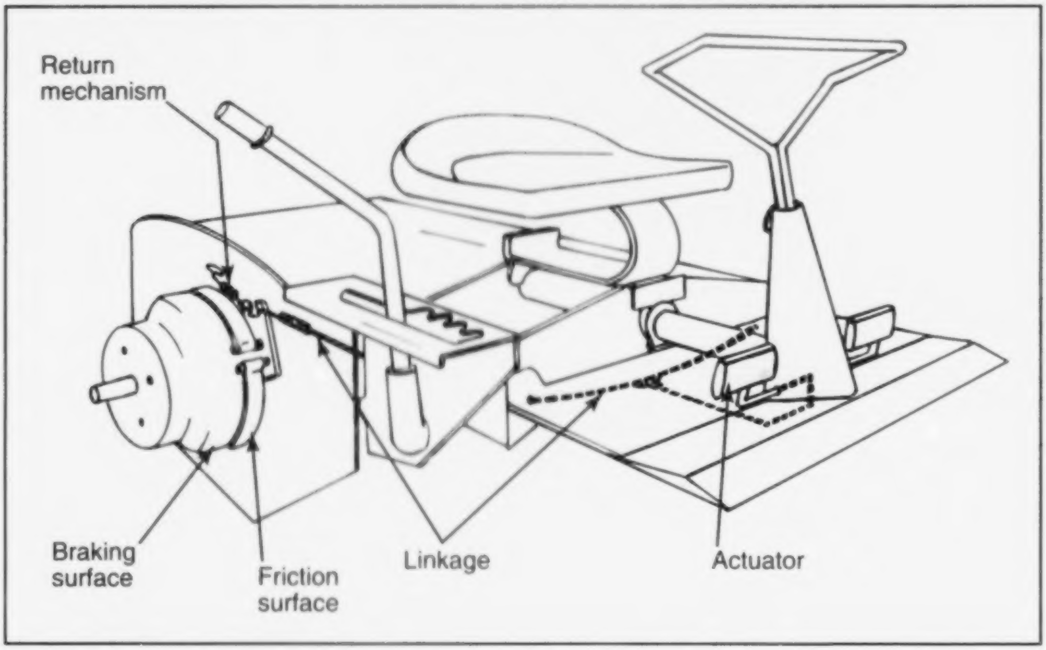
  Note: Some types of power product equipment use power from the engine to stop the motion of the vehicle by reversing the direction of the drive wheels. Because this is essentially a drive-train function, no special procedures are required for this design nor additional concepts beyond what you studied in Units 2 and 4 on drive trains. No further information is presented in this unit regarding engine-braking systems.

Information Sheet

9. **Major components of mechanical brake systems and their functions** (see Figure 10)

Note: The three main types of mechanical brake systems used for power product equipment are the external-band, the drum, and the disc designs (see Objective 10). The external-band design was one of the earliest used and is still popular on riding lawn mowers and small garden tractors. Larger types of equipment are more likely to use the drum design, with disc systems being used in some applications. Due to its popularity, the external-band design is shown here in Figure 10. Several of the components are common to all three types, with the primary difference being in the type of friction surface used. The operation of each type is described in Objective 10.

Figure 10: Major components of mechanical brake systems



- **Actuator**—Allows the operator to apply the brakes

  Note: Power product equipment brake systems normally have foot-operated pedals, but hand levers are also used.

- **Linkage**—Connects the actuator to the friction surface

  Note: The most common forms of mechanical linkages in power product equipment brake systems are cables and rods and combinations of cables and rods. These linkages often contain turnbuckles or other devices that allow the length of the linkage to be adjusted to allow proper brake pressure.

- **Friction surface**—Applies pressure to the braking surface

  Note: The friction surface and braking surface are the primary design features of mechanical brake systems that define the type of system. Most friction surfaces have a slightly abrasive substance mounted to them to provide friction upon application. This lining wears away as the brakes are used and must be replaced periodically. The lining also reduces the buildup of heat during brake application.

Information Sheet

- **Braking surface**—Fastens to the wheel or drive mechanism so that application of the brake will cause the wheel or mechanism to slow

  Note: Braking surfaces are attached to the mechanism that is to be slowed or stopped, whether that is a tire and wheel assembly or a transmission shaft.

- **Return mechanism**—Causes the friction surface to move away from the braking surface when the actuator is released

  Note: The most common mechanical return mechanism is the spring, though some systems use the linkage to return the friction surface.

10. Types of mechanical brake systems and their descriptions

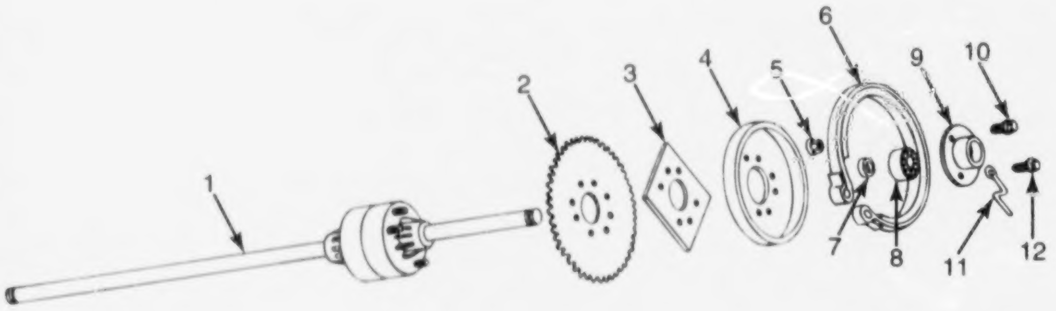
- **External band** (see Figure 11)—System in which actuating the brake causes a friction band to tighten around a drum mounted on a drive axle

  Note: As shown in Figure 11, the external-band brake system consists of a band of metal, often with an inner friction surface. The band tightens around an extension to the drive axle.

- **Drum** (see Figure 12 on the next page)—System in which actuating the brake causes one or more shoes to press against the inside of a drum mounted on a drive axle

  Note: The drum may be part of the wheel or a separate drum on an extension to the drive axle or other drive-train shaft similar to the hub used for an external-band design. In most designs, the shoes are inside the drum. The shoes are lined with a friction surface that wears away as the brakes are used so that the shoes have to be relined or, more often, replaced. In a few designs, the shoe is external to the drum and applied to the drum like an external band.

Figure 11: External-band mechanical brake system



1. Differential and axle assembly
2. Sprocket
3. Plate
4. Brake drum
5. Nut
6. Brake band
7. Spacer
8. Bearing
9. Bearing carrier
10. Screw
11. Brake-band stop
12. Screw

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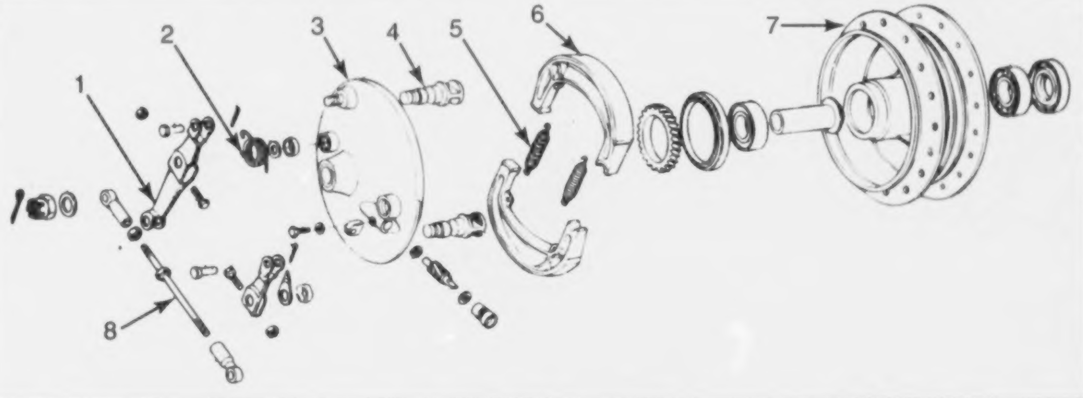
Information Sheet

Figure 12: Drum mechanical brake system



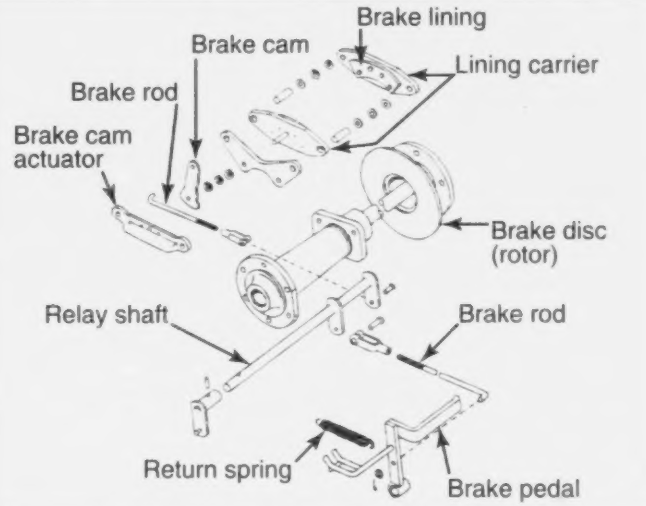
1. Cam lever
2. Return spring
3. Brake panel
4. Camshaft
5. Shoe spring
6. Brake shoe
7. Front hub
8. Connecting rod

Reproduced by permission of Kawasaki Motors Corporation, U.S.A., Irvine, California.

- **Disc (rotor)** (see Figure 13)—System in which actuating the brake causes a caliper device to squeeze a disc on a portion of the drive train, such as a chain-drive sprocket

  Note: A caliper is a device that closes like the jaws of a vise or pliers—both sides may move, or one side may move and the other remain stationary. The caliper closes on a disc or rotor with pads of friction material that wear away as the brakes are used and require periodic replacement. For power product equipment, the disc may be part of the drive wheel, part of the drive axle (including the drive-chain sprocket), a disc on any of the pulley drive shafts, or even a disc on the engine-output shaft. While used in mechanical brake systems, the disc design with wheel rotors is also used in hydraulic brake systems.

Figure 13: Disc mechanical brake system


Brake lining
Brake cam
Lining carrier
Brake rod
Brake cam actuator
Brake disc (rotor)
Relay shaft
Brake rod
Return spring
Brake pedal

Information Sheet

11. Principles of operation of mechanical brake systems

- The operator actuates a pedal or lever.
- The actuator is connected to a chain or cable or to linkages that allow movement of the braking mechanism—such as a shoe, pad, or band—to apply friction to one or more wheels or axles.

  Note: In external-band designs, the band tightens on the brake hub. In disc designs, the pads squeeze against the rotor. The shoes of drum brakes press against the drum.
- The friction applied to the wheel or axle causes it to turn more slowly and eventually to stop if friction continues to be applied.
- When the actuator is released, springs or other mechanisms move the friction surfaces away from the braking surface so that friction on the wheel or axle is reduced and the wheel is free to turn.

12. Typical service procedures required for mechanical brake systems

- **Adjust linkages**

  Note: The friction surface is normally only a slight distance from the braking surface, so the travel of the external band, shoes, or pads is only a fraction of an inch. Therefore, it is essential that the linkages be properly adjusted so that adequate friction is produced when the brakes are applied and so that they break contact when the brakes are released.
- **Lubricate actuating mechanism**
- **Replace friction surfaces**

  Note: Most mechanical brake systems have friction surfaces that are lined with a material that is designed to wear away with use, though this is not always the case with external-band designs. The friction surface not only provides better stopping power, but it helps to dissipate the heat that builds up during braking. This heat can be severe enough to weaken or warp metal parts, especially if they are cooled quickly by water or snow. Thus, the friction surface serves also to lessen the amount of heat absorbed by the metal parts. These surfaces are designed to be replaced if they become damaged or excessively worn. While some facilities may replace the linings of brake shoes, which are generally riveted into place, most simply replace the entire shoe or the pads in disc systems and bands in external-band systems.
- **Refinish braking surface**

  Note: For braking to be adequate, the braking surface must fit the shape of the pad, shoe, or band. The braking surface cannot be warped, scratched, pitted, or rusted or braking may be inadequate, produce too much heat, or be spongy when braking and releasing. If such damage is not severe, the brake surface can often be refinished (restored to a desired surface condition) using emery cloth or machining techniques.
- **Replace linkages**
- **Replace braking surface**

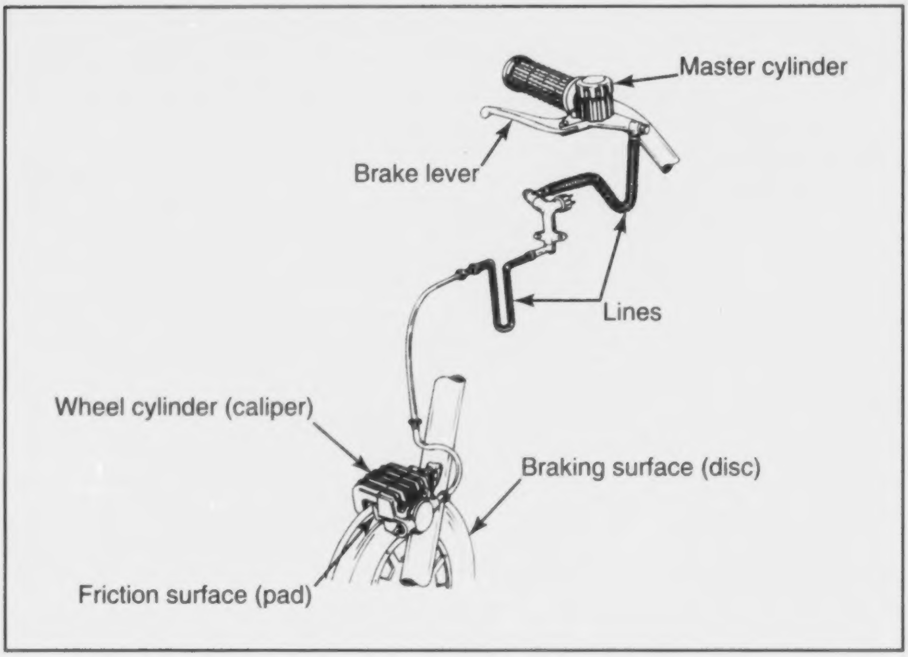
  Note: If an adequate braking surface cannot be provided by refinishing or if the braking surface has damage such as cracks, the braking surface should be replaced.

Information Sheet

13. **Major components of hydraulic brake systems and their functions** (see Figure 14)

Note: Every hydraulic brake system has mechanical components. In essence, the hydraulic portion of the system merely substitutes for the linkage of a mechanical system; the actuator and braking components are likely to be nearly the same. Generally, these systems use disc or drum designs for the actual braking. The main difference is that a hydraulic piston is used to generate the force that applies the friction surface to the braking surface. The hydraulic portion of the system is consistent with the hydraulic principles that you studied in Unit 3. Since the components are essentially the same, a disc system from a motorcycle is used here as a representative hydraulic system.

Figure 14: Major components of hydraulic brake systems



- **Brake lever**—Allows the operator to apply or release the brakes by moving the primary piston to force fluid through the system

  Note: In the motorcycle system illustrated in Figure 14, a lever is used, which corresponds to the actuator of a typical hydraulic system. In some equipment, the actuator is a foot pedal similar to that generally used in automobile hydraulic brake systems.

- **Master cylinder**—Stores the fluid for use in the brake system and houses the primary piston

  Note: The master cylinder corresponds to the reservoir and cylinder of a typical hydraulic system. The master cylinder holds a small supply of fluid. When the primary piston is actuated, a small volume of fluid is pushed through the system to actuate the brakes.

- **Lines**—Carry the fluid through the system

  Note: The generic term *lines* is used to refer to both metal lines and the reinforced rubber hoses that are used for hydraulic brake systems.

- **Wheel cylinders**—House the piston that responds to pressure from the primary piston to apply the brakes

  Note: There is normally a cylinder at each wheel equipped with brakes. The cylinder houses a piston that reacts to the movement of fluid through the system when the primary piston shifts in the master cylinder. For disc brakes, the wheel cylinder is normally referred to as a *caliper*.

- **Friction surface**—Makes contact with the moving component to cause it to slow or stop

  Note: The piston of the wheel cylinder has a rod or mating surface that extends beyond the hydraulic portion of the system so that the remaining components are mechanical. The most common types of friction surfaces used on power product equipment hydraulic brake systems are shoes and pads.

- **Braking surface**—Provides the contact area for the friction surface

  Note: If the system uses shoes, the braking surface is normally a drum, while disc-brake systems use a rotor and pads.

- **Return mechanism**—Breaks the contact between the friction surface and the braking surface when the brake actuator is released

  Note: Most drum-brake systems use springs as the return mechanism while many disc systems rely on the pressure of the turning rotor to push the pads back once the hydraulic pressure is released.

14. Principles of operation of hydraulic brake systems

- Actuating a lever or pedal causes a piston in a hydraulic cylinder to move.

  Note: The hydraulic system normally has a reservoir called the *master cylinder* from which fluid is dispensed.

- The movement of the piston applies pressure to the hydraulic fluid, which transmits force through the system.

- System pressure causes the pistons at one or more wheels to move in their cylinders.

  Note: Generally, each drive wheel will have a braking mechanism. In most cases, a single wheel cylinder is located in each wheel.

- The wheel-cylinder pistons are connected to a friction surface, such as a shoe or pad, and this movement causes the friction surface to contact a braking surface, such as a drum or disc, that is mounted to the wheel or drive axle.

  Note: For drum brake systems, the wheel cylinder piston pushes one shoe against the drum while a mechanical linkage from the first shoe causes the second shoe to push against the drum. In some systems, the cylinder is equipped with two pistons, each of which acts on a separate shoe. For disc designs, one or both of the pads may be moved by a piston to make contact with the disc.

- The friction applied to the wheel causes it to turn more slowly and eventually to stop if friction continues to be applied.

Information Sheet

- When the actuator is released, springs or other mechanisms move the friction surfaces away from the braking surface so that friction on the wheel or axle is reduced and the wheel is free to turn.

  Note: In some cases, especially in some disc systems, the rotation of the wheels is the only force used to return the friction surfaces.

- The pistons in the hydraulic system return to their normal positions and system pressure is equalized.

15. Types of disc- and drum-brake hydraulic-cylinder designs and descriptions of how they function

Note: Hydraulic fluid normally flows from a master cylinder (reservoir) to a cylinder at the wheel. The wheel cylinder contains one or more pistons that move the friction surfaces into contact with the rotor or drum.

- **Types of disc-brake hydraulic-cylinder designs**

  Note: The hydraulic cylinder in a disc brake system is normally referred to as a *caliper.*

  - **Fixed-caliper design**—Hydraulic fluid flows into the caliper and pushes two pistons—one from each side—into contact with the rotor
  - **Floating-caliper design**—Hydraulic fluid flows into the caliper and pushes one piston against the rotor with the caliper sliding a short distance so that a fixed brake pad also contacts the rotor

- **Types of drum-brake hydraulic-cylinder designs**
  - **Single-piston wheel cylinder**—Hydraulic fluid flows into the cylinder to push the piston, which in turn pushes the shoes into contact with the drum
  - **Dual-piston wheel cylinder**—Hydraulic fluid flows into the cylinder and pushes outward on two pistons, each of which pushes a shoe into contact with the drum

16. Typical service procedures required for hydraulic brake systems

- Adjust linkages
- Lubricate actuating mechanism
- Replace friction surfaces
- Refinish braking surface
- Replace linkages
- Replace braking surface
- Adjust fluid level

  Note: Leaks, overheating, brake-system service, and other conditions may require that fluid be added or removed from the system. Do not reuse fluid that is removed from a brake system; dispose of it properly. If fluid is to be added, ensure that it is the correct type of fluid. Remaining fluid should be properly stored in a tightly capped container. Brake fluid readily absorbs water from the air and must be protected from humidity.

Information Sheet

- Bleed brake system

  Note: Any time a closed hydraulic system is opened, the system must be bled to remove the air that may have become trapped in the system. Air bubbles trapped in the fluid compress like other gases, absorbing some of the force that is supposed to be transmitted through the fluid.

- Flush brake system

  Note: Flushing is the removal of all the fluid in a system under force so that it can be replaced with clean, uncontaminated fluid. Some manufacturers recommend that the brake system be flushed every year for some pieces of equipment. Never reuse fluid removed from a hydraulic system.

- Repair system leaks

- Replace hydraulic hoses

17. Safety rules for performing brake-system repair

- **Use proper procedures for handling, repairing, and disposing of brake components that contain or may contain asbestos.**

  Note: As with clutch plates, some old or foreign-made friction surfaces may contain the cancer-causing substance asbestos. Follow your facility's asbestos-handling procedures. Avoid breathing dust from such brake systems.

- **Avoid getting brake fluids in your eyes and mouth; follow label instructions for first aid in the event of an accident.**

  Note: Most brake fluids can burn or irritate the eyes and many are poisonous if swallowed. Additionally, brake fluids can severely damage equipment finishes, so use care not to spill fluid on painted surfaces or to touch them with fluid-contaminated cloths, clothing, parts, or tools.

- **Use care in handling brake-system springs, which can break or fly off their fasteners and present flying-object dangers.**

  Note: Springs, clips, bands, and similar mechanisms are often under tension or must be stretched or deformed in order to be installed or removed. This presents a danger because if these mechanisms slip or break, they can fly through the air with a great deal of force. This presents a hazard not only to the service technician but also to other people in the area.

- **Keep fingers and other body parts clear of braking mechanisms that may be actuated.**

  Note: Be careful not to apply hydraulic pressure that can actuate brake components or to release parts that will be returned by springs or other devices; there is a danger of crushing or cutting your fingers or other body parts.

- **Do not contaminate friction surfaces or braking surfaces with oils, grease, or other contaminants that can reduce braking effectiveness.**

  Note: Brakes work by the friction generated when the brakes are applied. If the friction surfaces or braking surfaces are contaminated with oil, grease, or other substances that reduce friction, braking effectiveness will be lessened. Further, contaminants can interfere with the dissipation of heat from the brakes, which could lead to warping or cracking or delamination of the friction lining.

Information Sheet

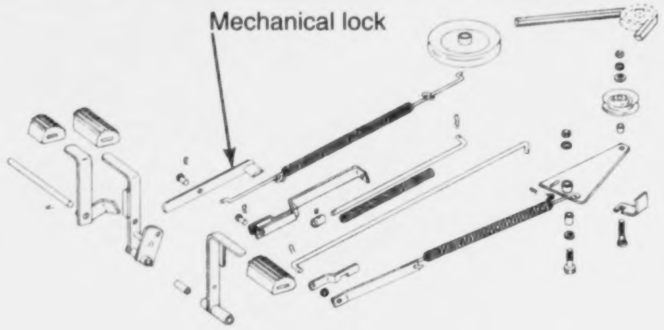
18. Types of parking brakes used in power product equipment

Note: Some types of self-propelled power product equipment have parking brakes that can be applied and locked to prevent the wheels from turning without the operator's continuing to apply the service brakes. Parking brakes are generally mechanical systems, no matter what type of service-brake system the equipment has. In some cases, a parking brake is simply a device that holds the service brakes engaged (mechanical lock), while in other designs a separate parking brake is provided (independent actuator). Often, too, equipment with hydrostatic transmissions offer hydrostatic lock in that the drive wheels will not move without a flow of fluid. Most hydrostatic transmissions have a relief valve that can be positioned to allow the equipment to roll.

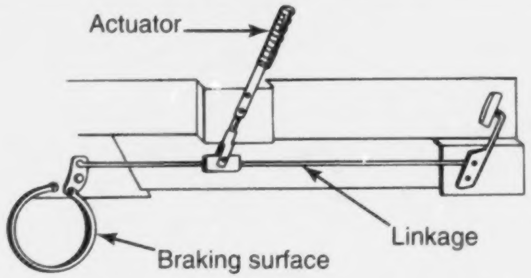
The only difference between most mechanical-lock systems and the service-brake system for that system is the locking mechanism. This device is generally a lever or hook that props or holds the service-brake actuator in the applied position. Independent-actuator systems may use many of the same components as the service-brake system, such as having a lever separate from the brake pedal that also engages an external-band brake or having a cable that mechanically actuates the shoes of a hydraulic brake system.

- **Mechanical lock** (see Figure 15-a)
- **Independent actuator** (see Figure 15-b)

Figure 15: Types of parking brakes



a. **Mechanical-lock parking brake**



b. **Independent-actuator parking brake**

Figure 15-a reproduced by permission of Deere & Company. Copyright 1993. All rights reserved, Deere & Company, Moline, Illinois.

Information Sheet

19. Typical service procedures required for parking brakes

Note: For parking brakes that use service-brake-system parts, service procedures applicable to service brakes will also be applicable to the system parking brake. Other procedures will include those associated with the parking-brake actuator.

- Adjust actuating mechanism
- Replace actuating-mechanism components
- Free frozen actuator parts

  Note: Through lack of use, exposure to the elements, and accumulations of grime and debris, parking-brake systems may become stuck in a given position. Cables may bind or become pinched. Levers, pedals, and other actuators may rust in place or get locked in place by wedged debris. These problems may require service to make the system usable.

Wheel and Brake Systems
Unit 5

Assignment Sheet 1—Determine Tire-and-Wheel-System Service Specifications and Parts Requirements

Name ______________________________ Date ______________

Evaluation criteria	**Rating**
Directions have been followed.	______
Minimum of 85 percent of answers are correct.	______
Overall rating	______

Evaluator's comments ______________________________

____

____

Introduction

Many types of power product equipment have wheels and tires, and there are nearly as many tire and wheel designs as there are functions performed by power product equipment. These functions may be as simple as supporting a walk-behind lawn mower or as complex as providing the drive, steering, braking, and support for an all-terrain vehicle. In a case where the tire and wheel assembly performs numerous functions, the assembly probably must interface with several other systems, such as the brake system, drive train, steering and suspension systems, etc. Another variable that can complicate tire-and-wheel service is that a piece of equipment is likely to have more than one type of tire and wheel—as is the case in front-wheel steering and rear-wheel drive. In this assignment sheet, you will practice selecting parts and determining specifications for equipment that you are likely to service in your career as a power product equipment technician.

Exercise

Directions

Using the resources available in your facility, determine the part numbers and specifications requested in the following questions/items. Write your answers on the blank lines provided with each question/item.

Assignment Sheet 1

1. Determine the part numbers for the right-front wheel for the walk-behind lawn mowers listed below.

   a. Ariens 21-inch without self-propelled drive

   Part number — ____________________

   b. Ariens 21-inch with disc self-propelled drive

   Part number — ____________________

   c. Ariens 21-inch with chain self-propelled drive

   Part number — ____________________

2. What is the recommended tire pressure for the front tires on the following pieces of equipment?

   a. Case/Ingersoll 8-HP riding lawn mowers

   Tire pressure — ____________________

   b. Jacobsen RMX model riding lawn mowers

   Tire pressure — ____________________

   c. MTD Model 400 lawn tractor

   Tire pressure — ____________________

3. What lubricant is recommended for the front wheels on the following equipment?

   Note: If the equipment uses sealed or plastic bearings that do not require lubrication, write "Not required."

   a. Ford Model R8 riding lawn mowers

   Lubricant — ____________________

   b. Snapper 3300 series riding lawn mowers

   Lubricant — ____________________

   c. Cub Cadet 1100 series riding lawn mowers

   Lubricant — ____________________

   d. Gravely 1100 series riding lawn mowers

   Lubricant — ____________________

   e. Sears-Craftsman 500 series riding lawn mowers

   Lubricant — ____________________

Assignment Sheet 1

4. Describe how the drive wheel is mounted to the drive axle for the following machines.

   a. Ford Model R8 riding lawn mowers

      Wheel mounting — ______________________

      ____

   b. Gravely riding lawn mowers

      Wheel mounting — ______________________

      ____

   c. Hustler Model 261 riding lawn mowers

      Wheel mounting — ______________________

      ____

   d. Massey-Ferguson 800 series riding lawn mowers

      Wheel mounting — ______________________

      ____

   e. Sears-Craftsman 500 series riding lawn mowers

      Wheel mounting — ______________________

      ____

Wheel and Brake Systems
Unit 5

Assignment Sheet 2—Determine Brake-System Service Specifications and Parts Requirements

Name ______________________ Date ______________

Evaluation criteria	**Rating**
Directions have been followed.	______
Minimum of 85 percent of answers are correct.	______
Overall rating	______

Evaluator's comments ______________________

____

____

Introduction

Riding lawn mowers, garden tractors, all-terrain vehicles, motorcycles, and other operator-driven equipment powered by small engines must provide a means of slowing and stopping vehicle movement for the safety of the operator and those in the work area. This function is normally performed by a brake system that may include hand- or foot-operated service brakes and separate parking brakes. Brake systems are designed for specific applications—that is, they must be powerful enough to stop the equipment in a safe, timely manner without being a significant load, and they must provide a means of actuation that is convenient to use for the way that the equipment is operated. Consequently, brake systems that appear to be similar even though installed on different pieces of equipment often have unique parts and specification requirements. In this assignment sheet, you will practice selecting parts and determining specifications for equipment that you are likely to service in your career as a power product equipment technician.

Exercise

Directions

Using the resources available in your facility, determine the part numbers and specifications requested in each of the following questions/items. Write your answers on the blank(s) provided with each question/item.

Assignment Sheet 2

1. Figure 1 below illustrates a Sears-Craftsman Model 502.256141 11-HP riding-lawn-mower brake assembly. The brake operates by pressing a friction pad against the disc labeled 2.

   a. What is the specified clearance between the pad and disc?

   Clearance — ______________________________

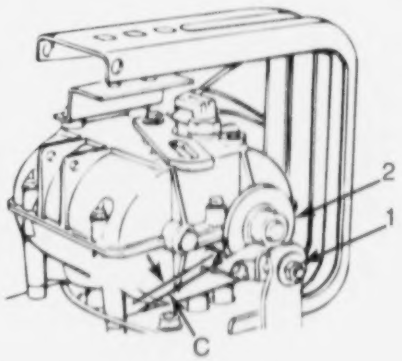
   b. How is the clearance adjusted?

   Clearance adjustment — ______________________________

   ____

   ____

Figure 1: Sears-Craftsman brake assembly



Reproduced by permission of Sears-Craftsman, Chicago, Illinois.

Assignment Sheet 2

2. Figure 2 below is an exploded view of a caliper brake used on many MTD riding lawn mowers, such as Models 380, 480, 525, and 797 to name a few.

   a. What is the adjustment procedure for this brake?

   Adjustment procedure — ______________________________

   ____

   ____

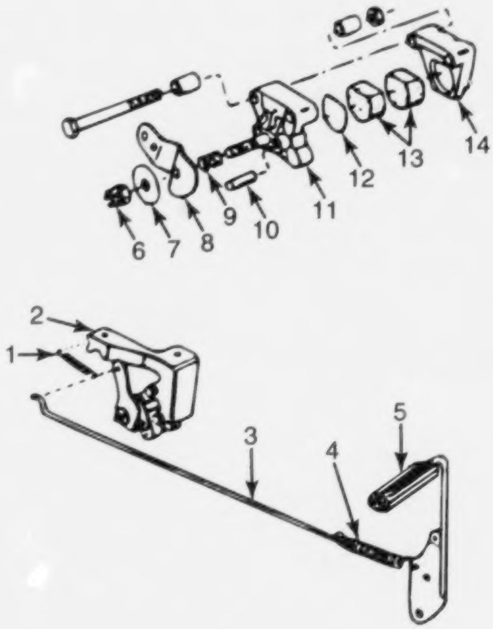
   ____

   b. Part 10 in the drawing is an actuating pin. How is it to be installed?

   Actuating-pin installation — ______________________________

   ____

Figure 2: Caliper brake (exploded view)



1. Return spring
2. Caliper assembly
3. Brake rod
4. Brake tension spring
5. Brake pedal
6. Adjusting nut
7. Washer
8. Cam lever
9. Spring
10. Actuating pin (2)
11. Carrier (outer)
12. Back-up plate
13. Brake pads
14. Carrier (inner)

Reproduced by permission of Mike Barnett, MTD Products, Inc., Cleveland, Ohio.

Assignment Sheet 2

3. Figures 3-a and 3-b below show a disc-brake assembly used on International Harvester Cadet riding lawn mowers, such as Models 55, 75, 85, and 95. Figure 3-a is an exploded view of the brake assembly, while Figure 3-b is a detail of the brake adjusting screw.

   a. What is the part number for the inner pad (Item 8 in Figure 3-a)?

   Part number — ______________________________

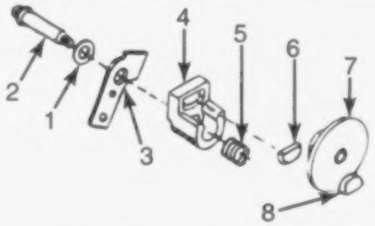
   b. What is the part number for the outer pad (Item 6 in Figure 3-a)?

   Part number — ______________________________

   c. When properly adjusted, what should the distance indicated by "A" in Figure 3-b be?

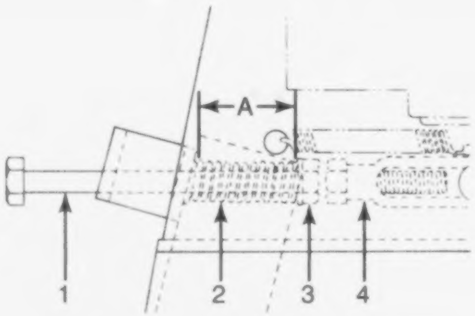
   Distance — ______________________________

Figure 3: International Harvester disc-brake assembly



a. **Disc-brake assembly** (exploded view)

1. Washer
2. Shoulder bolt
3. Cam lever
4. Caliper
5. Spring
6. Brake pad (outer)
7. Brake disc
8. Brake pad (inner)



b. **Disc-brake adjusting screw** (detail)

1. Adjusting bolt
2. Spring
3. Jam nut
4. Clevis

Drawings in Figure 3-a and Figure 3-b reproduced by permission of Mike Barnett, MTD Products, Cub Cadet Corp., Cleveland, Ohio.

Assignment Sheet 2

4. Figure 4 below shows the adjustment of the brake on a Wheel Horse Model B-115.

   a. What happens when the brake pedal is partially depressed?

   ____

   ____

   b. What happens when the brake pedal is fully depressed?

   ____

   ____

   c. What should the distance D be when properly adjusted?

   Distance — ______________________________

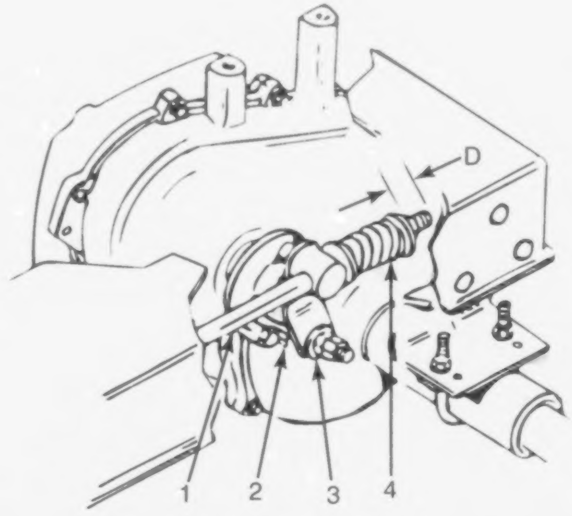
   d. How much travel should there be in the brake rod before the brake pads contact the disc?

   Travel — ______________________________

   e. What part is labeled 3?

   Part — ______________________________

Figure 4: Wheel Horse Model B-115 brake adjustment



1. Brake rod
2. Disc-brake assembly
3. Adjusting nut
4. Spring

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Assignment Sheet 2

5. Figure 5 on the next page illustrates the brake system of a Wheel Horse Model A-90 special garden tractor.

   a. Two pedals are shown. Which item number is the brake pedal?

      Item number — ______________________

   b. How is the parking brake engaged?

      ____

      ____

   c. The brake is adjusted by changing the length of one of the brake rods. Is it Item 14, 21, or 22?

      Item number — ______________________

   d. Proper brake adjustment occurs—(Circle the correct answer below.)

      When the wheels skid with the parking brake engaged

      With the adjusting screw tightened one-half turn beyond when the wheels skid with the parking brake engaged

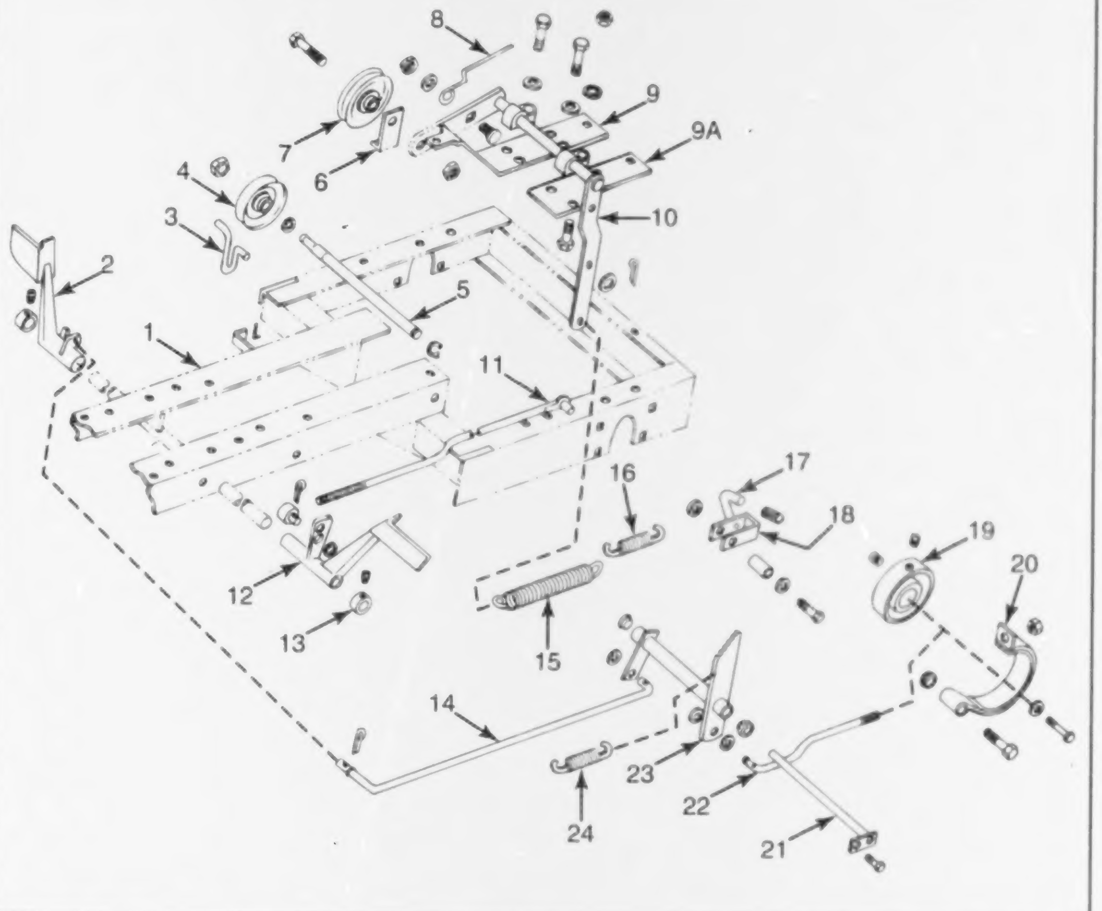
      With the adjusting screw loosened one-half turn once the wheels skid with the parking brake engaged

   e. Which spring is the brake-return spring: Item 15, 16, or 24?

      Item number — ______________________

Assignment Sheet 2

Figure 5: Wheel Horse Model A-90 special clutch and brake system



1. Frame
2. Brake pedal
3. Belt guide
4. Idler pulley
5. Idler shaft
6. Belt guide
7. Idler pulley
8. Guide stop
9. Torque bar

9A. Support
10. Idler-arm assembly
11. Clutch rod
12. Clutch pedal
13. Retainer collar
14. Brake-link rod
15. Clutch spring
16. Pawl-return spring
17. Pawl lever
18. Park-brake pawl
19. Brake drum
20. Brake band
21. Pivot-rod assembly
22. Brake rod
23. Bellcrank assembly
24. Brake-return spring

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Wheel and Brake Systems
Unit 5

Job Sheet 1—Service Tires and Rims

Introduction This job sheet covers the routine maintenance associated with servicing tires and rims. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inflate tires to required pressure
- Remove and replace a tire and wheel assembly
- Mount and demount tires
- Repair tires

Procedure

1. Study Objectives 1 through 7 in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of servicing tires and rims and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses tires and rims.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 1

Worksheet—Service Tires and Rims

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 1

Worksheet—Service Tires and Rims

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Wheel and Brake Systems
Unit 5

Job Sheet 2—Service Wheel Bearings and Bushings

Introduction This job sheet covers the routine maintenance associated with servicing wheel bearings and bushings. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Lubricate bearings and bushings
- Remove and replace bearings and bushings
- Pack bearings
- Adjust bearings

Procedure

1. Study Objectives 1 through 7 in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of servicing wheel bearings and bushings and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses wheel bearings or bushings.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 2

Worksheet—Service Wheel Bearings and Bushings

Name ______________________ Attempt number ________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 2

Worksheet—Service Wheel Bearings and Bushings

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	________
Procedures completed correctly.	________
Proper tools used correctly.	________
Safety precautions observed.	________
Service meets specifications.	________
Clean-up and follow-up actions adequate.	________
Overall rating	________

Evaluator's comments ____

____

____

Wheel and Brake Systems
Unit 5

Job Sheet 3—Perform Routine Maintenance on Mechanical Brakes

Introduction

This job sheet covers the routine maintenance associated with mechanical brakes. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect mechanical-brake components
- Lubricate chains and linkages
- Adjust linkages and brake components

Procedure

1. Study Objectives 8 through 19 in the information sheet and complete Assignment Sheet 2.
2. Watch your instructor's demonstration of performing routine maintenance on mechanical brakes and any supporting media provided by your instructor.
3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one type of mechanical brake. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.
4. Ask your instructor to provide you with power product equipment that uses mechanical brakes.
5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.
6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.
7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 3

Worksheet—Perform Routine Maintenance on Mechanical Brakes

Name ______________________ Attempt number ________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 3

Worksheet—Perform Routine Maintenance on Mechanical Brakes

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Wheel and Brake Systems
Unit 5

Job Sheet 4—Repair Mechanical Brakes

Introduction

This job sheet covers the repair procedures associated with mechanical brakes. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace mechanical brake-system components, including shoes, pads, bands, calipers, drums, discs, etc.
- Refinish brake surfaces, including drums and discs
- Perform adjustments to return equipment to original specifications

Procedure

1. Study Objectives 8 through 19 in the information sheet and complete Assignment Sheet 2.

2. Watch your instructor's demonstration of repairing mechanical brakes and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one type of mechanical brake. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses mechanical brakes.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 4

Worksheet—Repair Mechanical Brakes

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 4

Worksheet—Repair Mechanical Brakes

Part B: Performance evaluation

Evaluation criteria	Rating
Correct procedures identified for assigned equipment.	
Procedures completed correctly.	
Proper tools used correctly.	
Safety precautions observed.	
Service meets specifications.	
Clean-up and follow-up actions adequate.	
Overall rating	

Evaluator's comments ____________________

Wheel and Brake Systems
Unit 5

Job Sheet 5—Perform Routine Maintenance on Hydraulic Brakes

Introduction This job sheet covers the routine maintenance associated with hydraulic brakes. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect brake-system components
- Check fluid level and add fluid as required
- Lubricate mechanical components
- Adjust mechanical components

Procedure

1. Study Objectives 8 through 19 in the information sheet and complete Assignment Sheet 2.

2. Watch your instructor's demonstration of performing routine maintenance on hydraulic brakes and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one type of hydraulic brake. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses hydraulic brakes.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 5

Worksheet—Perform Routine Maintenance on Hydraulic Brakes

Name ______________________ Attempt number ________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 5

Worksheet—Perform Routine Maintenance on Hydraulic Brakes

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Wheel and Brake Systems
Unit 5

Job Sheet 6—Repair Hydraulic Brakes

Introduction

This job sheet covers the repair procedures associated with hydraulic brakes. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace mechanical components, including pads, calipers, discs, linkages, etc.
- Repair or replace seals, hoses, and lines
- Flush system
- Bleed system
- Overhaul master cylinder
- Overhaul wheel cylinders
- Resurface or replace disc
- Perform adjustments to return equipment to original specifications

Procedure

1. Study Objectives 8 through 19 in the information sheet and complete Assignment Sheet 2.

2. Watch your instructor's demonstration of repairing hydraulic brakes and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one type of hydraulic brake. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses hydraulic brakes.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 6

Worksheet—Repair Hydraulic Brakes

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 6

Worksheet—Repair Hydraulic Brakes

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ______________________________

____

____

Wheel and Brake Systems
Unit 5

Job Sheet 7—Perform Routine Maintenance on Parking Brakes

Introduction

This job sheet covers the routine maintenance associated with parking brakes. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect mechanical components
- Lubricate cables, rods, and linkages
- Adjust linkage

Procedure

1. Study Objectives 8 through 19 in the information sheet and complete Assignment Sheet 2.
2. Watch your instructor's demonstration of performing routine maintenance on parking brakes and any supporting media provided by your instructor.
3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one type of parking brake. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.
4. Ask your instructor to provide you with power product equipment that uses a parking brake.
5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.
6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.
7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 7

Worksheet—Perform Routine Maintenance on Parking Brakes

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 7

Worksheet—Perform Routine Maintenance on Parking Brakes

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Wheel and Brake Systems
Unit 5

Job Sheet 8—Repair Parking Brakes

Introduction

This job sheet covers the repair procedures associated with parking brakes. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace mechanical components, including cables, rods, levers, etc.
- Overhaul parking-brake subsystems, including brakes and actuators
- Perform adjustments to return equipment to original specifications

Procedure

1. Study Objectives 8 through 19 in the information sheet and complete Assignment Sheet 2.

2. Watch your instructor's demonstration of repairing parking brakes and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one type of parking brake. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a parking brake.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 8

Worksheet—Repair Parking Brakes

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 8

Worksheet—Repair Parking Brakes

Part B: Performance evaluation

Evaluation criteria **Rating**

Correct procedures identified for assigned equipment. ______

Procedures completed correctly. ______

Proper tools used correctly. ______

Safety precautions observed. ______

Service meets specifications. ______

Clean-up and follow-up actions adequate. ______

Overall rating ______

Evaluator's comments ____

____

____

Chassis and Steering Systems
Unit 6

Objective Sheet

Unit objective

After completing this unit, the student should be able to describe chassis designs and the design and operation of steering systems and be able to perform routine maintenance and service procedures for such systems. The student should demonstrate these competencies by completing the assignment sheet and job sheets and by scoring a minimum of 85 percent on the written test.

Specific objectives

After completing this unit, the student should be able to

1. Match the major components of chassis to their correct functions.
2. List typical service procedures required for chassis.
3. List types of steering systems used in power product equipment.
4. List types of steering-system configurations used in power product equipment.
5. State the functions of the major components of steering systems.
6. Describe the principles of operation of the types of gears used in steering systems.
7. List typical service procedures required for steering systems.
8. Determine chassis and steering-system service specifications and parts requirements. (Assignment Sheet 1)
9. Repair or replace chassis components. (Job Sheet 1)
10. Perform routine maintenance on mechanical steering systems. (Job Sheet 2)
11. Repair mechanical steering systems. (Job Sheet 3)
12. Perform routine maintenance on hydraulic steering systems. (Job Sheet 4)
13. Repair hydraulic steering systems. (Job Sheet 5)
14. Perform routine maintenance on drive-wheel steering systems. (Job Sheet 6)
15. Repair drive-wheel steering systems. (Job Sheet 7)

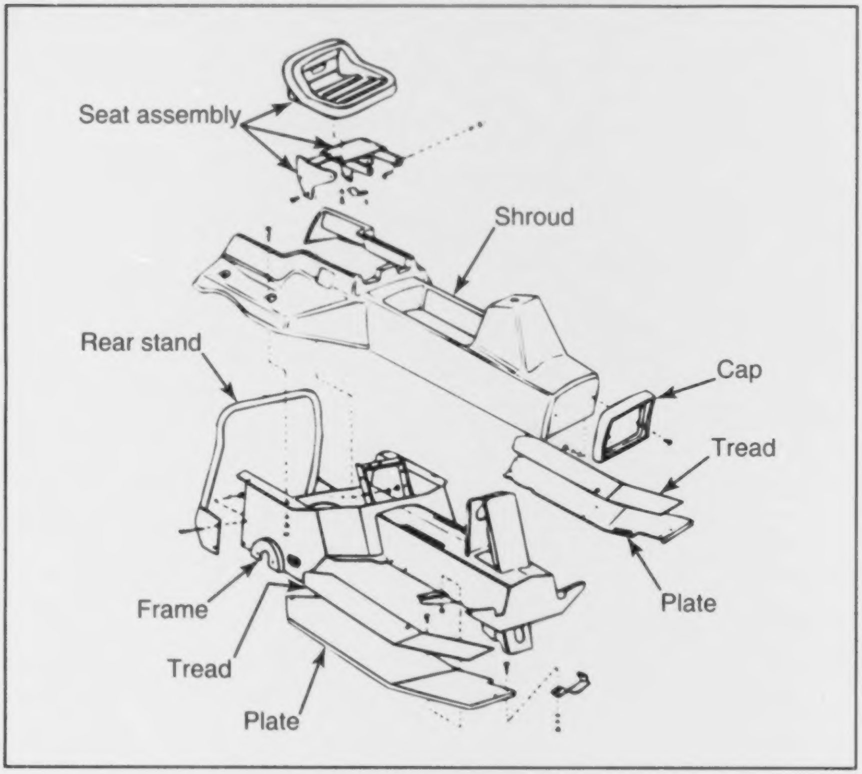
Chassis and Steering Systems
Unit 6

Information Sheet

1. **Major components of chassis and their functions** (see Figure 1)

Note: The chassis consists of those components that support the body parts and other components used to cover, brace, and protect the equipment systems and assist with operation of the equipment. Naturally, the specific design of chassis components will vary greatly depending on the type of equipment and its use; however, self-propelled equipment designs have a number of common features. The riding lawn mower illustrated in Figure 1 is representative of most operator-ridden equipment. It also shares features with smaller equipment. For example, while the frame and plate of a walk-behind mower are generally integrated into the mower deck, the engine is usually protected with a shroud and often a cap, and a tread is provided for the operator's foot for pull starting.

Figure 1: Major components of chassis



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- **Seat assembly**—Supports the rider

  Note: The seat assembly is reinforced to support the weight of the rider. For this reason, it is often used to provide a rigid cage for other components, such as the battery, engine (for rear-engine models), or hydraulic mechanisms.

Information Sheet

- **Shroud**—Protects the top and sides of the engine from dust, dirt, water, flying objects, and other debris, while also permitting the flow of cooling air

  Note: Three general configurations are used for engine placement in power product equipment: (1) The engine can be in the front, as is the case with most garden tractors, so that the engine is mounted over or nearly over the front wheels. (2) The engine can be mounted in the center with the engine between the front and rear wheels, as is done with most motorcycles and walk-behind lawn mowers. (3) The engine may be mounted in the rear, situated over or nearly over the rear wheels. Engine position affects the design of the equipment's shroud.

- **Rear stand**—Allows the equipment to be set up on its end or raised by the rear

  Note: The rear portion of most operator-ridden equipment is often reinforced to allow the mounting of equipment and towed attachments. For some equipment, the rear portion is specifically designed to allow the equipment to stand on its end for service or storage; however, the technician should follow the manufacturer's instructions with regard to fuel, oil, and other fluids and systems prior to standing a vehicle on its end. The rear portion of walk-behind equipment usually provides a reinforced section to which handlebars are mounted, allowing the operator a means of guiding and controlling the equipment.

- **Cap**—Supports the shroud and protects the engine while allowing cooling air to enter the front of the equipment

  Note: The cap of front-engine, operator-ridden equipment often contains a grill or other structure to improve cooling and appearance.

- **Frame**—Provides the rigid foundation to which the engine, chassis components, wheel system, and other systems are mounted

  Note: Four basic frame constructions are used for power product equipment: (1) Small equipment uses an integrated chassis, meaning that the frame and other equipment components are molded as one piece of material—usually cast aluminum, steel, or plastic. (2) Some walk-behind mowers and similar equipment use frames in which pieces of sheet metal have been welded together to form the frame. (3) Frames are also made from welded angle metal, channel, or tubing. Angle metal (angle iron) is formed of two flat metal strips joined at an angle of approximately 90 degrees. Channel (channel iron) is similar to angle metal but consists of three joined strips that form a U-shape in profile. Tubing is hollow metal that may be round, oval, rectangular, or square. (4) Another method for constructing chassis is to stamp the parts from metal.

- **Tread**—Provides the step the operator uses to board the equipment

- **Plate**—Supports the tread and provides a degree of lateral strength to the equipment

2. Typical service procedures required for chassis

- **Clean chassis components**

  Note: Cleaning the chassis components involves removing dirt, grease, oil, and other grime from the components. Dirt and grime are not only unattractive on the equipment, they also prevent the equipment from operating correctly and can lead to early failures. For example, if the moisture from mud gets trapped against metal parts, the parts will rust. If grass is trapped in the front of the grill, air will not circulate properly to cool the engine and the engine may overheat. If grime is allowed to accumulate on equipment parts, it can interfere with proper steering, braking, and other system operation.

Information Sheet

- **Inspect fasteners**

  Note: Fastener maintenance involves inspecting the equipment screws, springs, clevis pins, weld joints, and other fasteners to ensure that they are not loose, missing, or damaged and then tightening or replacing the fasteners as required.

- **Lubricate moving parts**

- **Refinish chassis to prevent rust and corrosion**

  Note: Refinishing chassis components involves repainting or replating the components and applying undercoating and other protective finishes to prevent oxidation (rust) and corrosion.

- **Maintain component alignment**

  Note: Chassis components can become misaligned through normal use, abuse, and accidents. If not corrected, misaligned components can result in loose fasteners, damaged frames, excessive wear, and even overheating.

3. Types of steering systems used in power product equipment

Note: The steering capabilities of the various types of wheeled power product equipment vary greatly. Steering capabilities range from rigid-wheel systems, such as those typically found on rotary mowers, to systems that allow the operator to change the direction of the wheels, to those that produce vehicle turns by rotating the drive wheels at different speeds.

- **Mechanical**

  Note: Most types of operator-ridden power product equipment use either a steering wheel or handlebars. These devices are mounted to the steering column, which is mechanically linked to the wheels, usually by rods. Turning the steering wheel or handlebars causes the wheels to pivot simultaneously.

- **Hydraulic**

  Note: Hydraulic steering systems function in much the same way that mechanical systems do; however, in hydraulic systems the steering rods are also connected to a hydraulic system that supplements operator efforts to turn the wheels, so less operator force is needed than would otherwise be required. Such systems are often referred to as *power-assisted steering* or simply *power steering.*

- **Drive wheel**

  Note: Some types of power product equipment achieve steering control by having the drive wheels turn at different speeds. The two most common methods of drive-wheel steering are (1) to use two chain or belt systems to turn the drive axles at different speeds or (2) to use two independent hydrostatic-drive systems. The equipment will turn in the direction opposite the faster-turning drive wheel. Operator control is usually provided by means of levers that control the drive axles independently. Some systems even allow the drive wheels to rotate in opposite directions. These designs permit a smaller turning radius, which is helpful in maneuvering equipment in tight areas and in turning around objects, such as when mowing around a tree.

4. Types of steering-system configurations used in power product equipment

- **Front-wheel steering** (see Figure 2-a)

  Note: The front-wheel configuration is the conventional steering system on power product equipment. This type of configuration provides operator control by turning the front wheels in the desired direction of the turn.

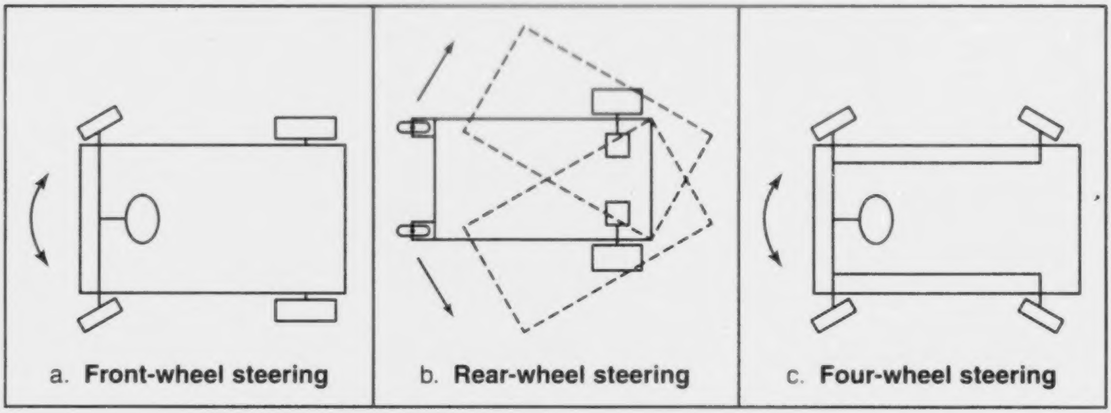
- **Rear-wheel steering** (see Figure 2-b)

  Note: The most-common rear-wheel steering design employs drive-wheel steering. Steering is achieved as the drive wheels turn at different speeds, by increasing the speed of one wheel, by decreasing the speed of one wheel, or by doing both. Other systems use a mechanical linkage that turns the rear wheels so that the wheels pivot in the opposite direction of the desired turn. Often equipment with rear-wheel steering will use a tricycle-wheel configuration—two wheels in back and one in front. The front wheel frequently is mounted in such a way that it can swivel 360 degrees, thus allowing the front end to follow any path based on the combined output of the drive wheels. Finally, steering is accomplished by pivoting the rear wheels in some equipment.

- **Four-wheel steering** (see Figure 2-c)

  Note: To achieve a tighter turning radius, some types of equipment use four-wheel steering. This design combines front- and rear-wheel mechanical-steering methods so that the front wheels pivot in the desired direction of the turn and the rear wheels pivot in the opposite direction. Some four-wheel steering systems link the front and rear wheels in such a way that gradual turns are made using only the front wheels to steer, while sharp turns (based on how much the steering wheel is turned) are made using both the front and rear wheels.

Figure 2: Steering-system configurations



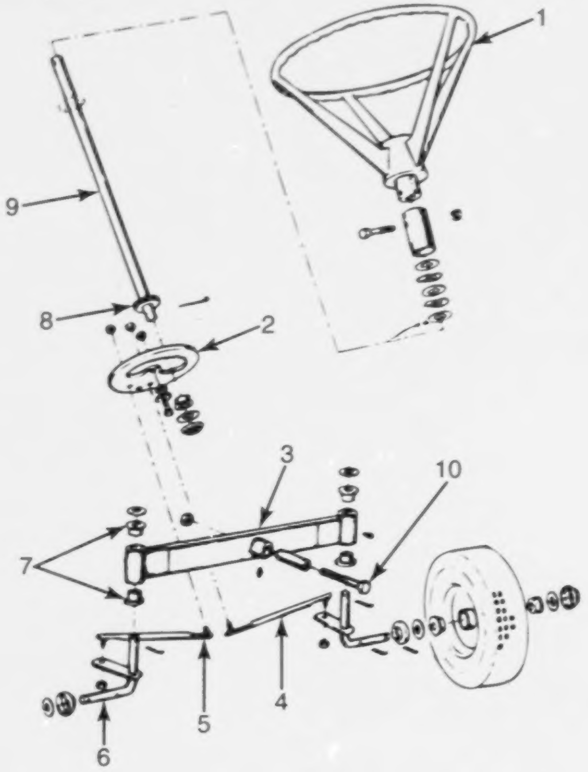
a. **Front-wheel steering** b. **Rear-wheel steering** c. **Four-wheel steering**

5. Major components of steering systems and their functions (see Figure 3 on the next page)

Note: Obviously, the components of steering systems are going to vary based on the type of steering system used and the configuration of the steering system. However, the majority of power product equipment use front-wheel mechanical systems such as the type illustrated in Figure 3. Most other designs have many comparable components with similar terminology applied to those systems.

Information Sheet

Figure 3: Major components of steering systems



1. Steering handle (steering wheel)
2. Steering gear (quadrant gear)
3. Main member
4. Tie rod (drag link)
5. Tie-rod end (drag-link arm)
6. Spindle (axle)
7. Spindle bearings
8. Steering-shaft linkage (pinion gear)
9. Steering shaft
10. Pivot pin

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- **Steering handle** (steering wheel)—Provides a means for the operator to control the left and right direction of travel

  Note: The riding lawn mower in Figure 3 uses a steering wheel. Other popular steering handles include handlebars, steering levers, and control sticks. Handlebars form a T with the steering shaft and are commonly used on motorcycles and walk-behind equipment. Steering levers are most often used in pairs on types of equipment that use drive-wheel steering—systems where turns are achieved by having the drive wheels turn at different speeds. Positioning the levers in various relationships controls the direction and speed of the drive wheels. Control sticks are used on some riding lawn mowers, ultralight aircraft, and other types of equipment that must make tight turns or frequent direction changes. The control stick pivots a full 360 degrees, and the motion of the vehicle is controlled by the exact position of the stick within the circle defined by its pivot range.

Information Sheet

- **Steering shaft**—Transmits force from the steering handle to the steering mechanism

  Note: In some designs, the steering handle and steering shaft are integrated into a single shaft, as in control sticks and steering levers.

- **Steering-shaft linkage** (pinion gear)—Transmits force from the steering shaft to the steering gear

  Note: The steering-shaft linkage is merely a means of mating the steering shaft with the steering gear. It often also changes the flow of force 90 degrees to assist in converting the shaft's rotary motion to lateral movement.

- **Steering gear** (quadrant gear)—Converts the rotary motion of the steering shaft into lateral motion

  Note: See Objective 6 for the types of gears used in steering-system designs.

- **Main member**—Provides the support for the axle components

- **Pivot pin**—Allows the main member to swivel to accommodate changes in the driving surface

  Note: The main member is generally a heavy piece of metal that is designed to stand up to the pounding forces that it must face. Because the vehicle may travel over terrain that is higher on one side than the other, the main member must allow the wheel on one side to ride higher than the other, hence the need for the pivot pin.

- **Spindle** (axle)—Pivots to change the direction of the steerable wheels

  Note: A spindle provides a true axle on which a wheel is mounted. There is a spindle on each side, and each is capable of pivoting independently (except for being connected by the tie rod). As the steering handle is turned, the steering gear or direct linkage is connected to the tie-rod end so that the spindle on that side is rotated by the action of the steering handle.

- **Spindle bearing**—Provides a reduced-friction surface against which the spindle can pivot

- **Tie rod** (drag link)—Transmits force from the steering gear to the pivot point of the steerable wheels; connects the left and right spindles and provides a method for adjusting the distance between the spindles to set the alignment of the steerable wheels

  Note: The tie rod joins the two spindles so that the movement of one spindle is reflected in the other. Normally, the tie rod is threaded on each end so that the tie-rod ends can be mounted on the tie rod and the distance between them is adjustable. This allows the wheel alignment to be adjusted.

- **Tie-rod end** (drag-link arm)—Connects the tie rod and spindles with ball joints so that the movement of the steering axle accommodates changes in the driving surface

  Note: A ball joint is a connection in which a metal ball fits into a cup (socket) that allows the ball to swivel over a wide range. The threaded stud on the tie-rod end uses a ball joint so that the stud can swivel. The threaded portion fits through a hole in the spindle so that a nut can be tightened down on the stud. Often the nut is held in place with a cotter pin.

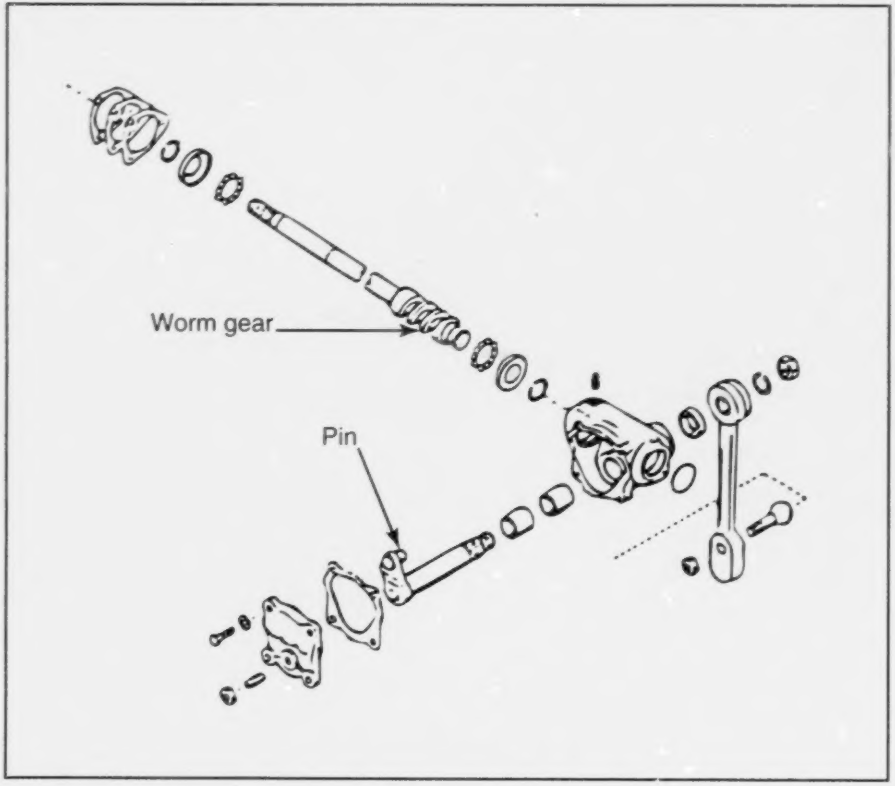
6. Principles of operation of the types of gears used in steering systems

Note: The steering systems used on power product equipment may be as simple as having the operator physically re-orient the equipment, as with a walk-behind lawn mower, or as complex as a system with hydraulic-assisted steering of all four wheels. For that equipment that offers a maneuverable steering system, designs vary most in the method used to transfer force from the rotation of the steering shaft to make the wheels pivot. The simplest method is similar to that used on motorcycles, where the axle is rigidly mounted to the steering shaft so that turning the steering handle results in a direct and equal amount of pivot in the wheel. For equipment with two front wheels, direct linkage involves the use of rods with one end of each rod mounted directly to the steering shaft. The choice of a steering-system design will vary with the weight of the vehicle, steering responsiveness required, cost, and manufacturer preferences. The quadrant-gear system is perhaps the most commonly used design for operator-ridden power product equipment. Worm-and-pin and rack-and-pinion systems are generally reserved for heavier, more expensive equipment. Most linkage and gear designs can be used with either mechanical or hydraulic systems.

- **Worm and pin**—The end of the steering shaft consists of a worm gear; the steering linkage includes an output shaft with a pin that rides in the worm gear so that the shaft rotates as the worm gear turns.

  Note: In a typical worm-and-pin installation, as the pin follows the worm gear, the output shaft pivots. This action is reflected in the wheels though linkages attached to the output shaft, such as the pivoting arm shown in Figure 4.

Figure 4: Worm and pin

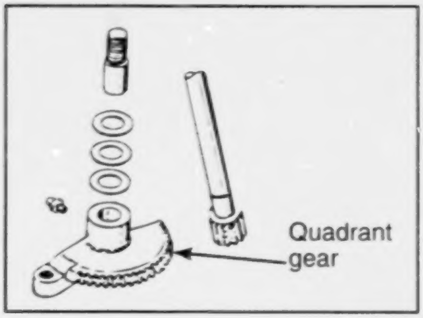


Information Sheet

- **Quadrant gear**—The end of the steering shaft consists of a pinion gear (usually beveled); the steering linkage is attached to a semicircular or quarter-circle gear that is rotated by the pinion gear.

  Note: The quadrant-gear design is one of the most commonly used steering-gear mechanisms for power product equipment, and it is found with numerous design variations. The steering gear itself forms an arc and usually consists of one-fourth to one-half of a circle. Because quarter circles are often used, the term *quadrant* has become popular, although the gear may also be referred to as a *sector gear* or *segment gear*. Though most configurations use quadrant gears with external teeth, other popular designs also include gears with internal teeth.

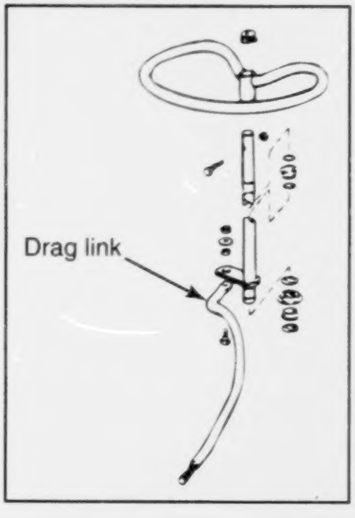
  Figure 5: Quadrant gear



- **Direct link**—The end of the steering shaft provides an attachment to the axle, either directly or through a drag link (see Figure 6), so that rotation of the steering shaft causes the wheel or wheels to pivot.

  Note: In a direct-link system, the steering column is attached directly to the axle, as with a motorcycle, or directly to the steering linkage as shown in Figure 6. No gear is used. Generally, the same amount of pivot is exerted on the axle as rotation is placed on the steering column by the operator.

  Figure 6: Direct link

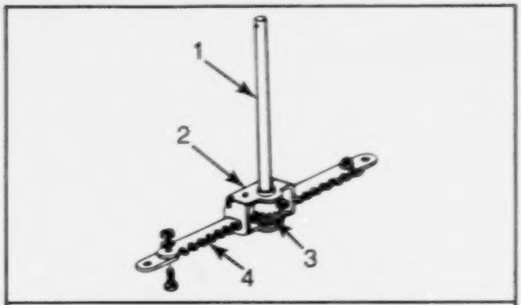


Information Sheet

- **Rack and pinion**—The end of the steering shaft is a pinion gear; the steering linkage is a flat, toothed bar called a *rack* that moves laterally as the steering shaft is rotated and attached to the axles so that the wheels pivot as the rack moves.

  Note: The primary advantage of the rack-and-pinion system is that the rack moves laterally. By linking each front wheel to one end of the rack, smooth pivots of the wheels can be accomplished. Systems that use curved gears lose some force in the directional changes of power transmission.

  Figure 7: Rack and pinion



1. Steering shaft
2. Housing
3. Pinion
4. Rack (2 piece)

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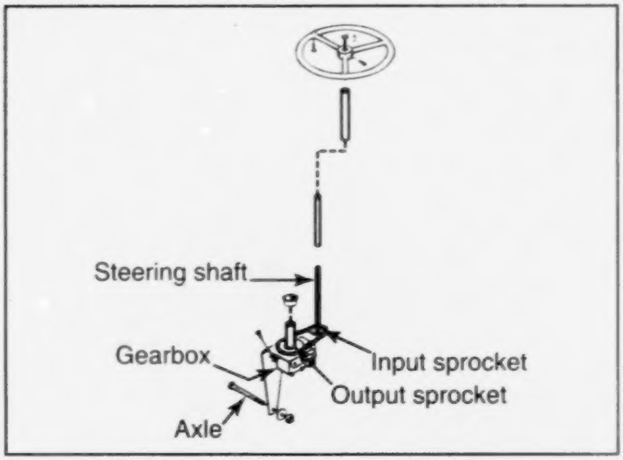
- **Chain and sprocket**—The end of the steering shaft is a sprocket; a chain connects the steering sprocket to an output sprocket that is attached to the steering axle or wheels.

  Note: The chain-and-sprocket system is similar to a quadrant-gear system, and the ratio between the diameters of the two sprockets can be used to multiply force. Some models of equipment that use this design provide the capability of turning the front wheel of a tricycle-wheel configuration 360 degrees.

  Figure 8: Chain and sprocket



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7. Typical service procedures required for steering systems

- **Align steering system, including toe-in**

  Note: Toe-in is the alignment of the front wheels of a vehicle in which the distance between the front portions of the wheels are closer together than the rear portions of the wheels. Service manuals for equipment with adjustable wheel alignment generally specify the amount of toe-in. Toe-in helps to provide good steering control while reducing stress and wear on tires. Some steering systems may specify a second feature known as *camber.* Camber is vertical alignment of the wheels. While the tires will normally be parallel to each other with regard to vertical lines through their hubs, some wheels are configured with the tops of the tires closer than the bottoms of the tires to create camber. The final aspect of wheel-assembly geometry is known as *caster.* Caster is the angle of the vertical portion of the spindle in relation to true vertical. Caster is not normally adjustable on power product equipment.

- **Align system components**

  Example: Align wheels to the centerline of the equipment

  Note: Alignment of steering components is generally referred to as *wheel alignment* or *front-end alignment.* Some equipment, such as riding lawn mowers and garden tractors, have adjustable wheel alignment—that is, the spacing of the front wheels can be changed slightly to provide improved steering, stability, tire wear, and other factors.

- **Lubricate moving parts**
- **Remove and replace steering gear**
- **Adjust linkages**
- **Adjust hydraulic and hydrostatic steering-belt tension**
- **Replace belts and chains**
- **Check and refill hydraulic-fluid reservoirs**

Chassis and Steering Systems
Unit 6

Assignment Sheet 1—Determine Chassis and Steering-System Service Specifications and Parts Requirements

Name ______________________________ Date ______________

Evaluation criteria **Rating**

Directions have been followed. ______

Minimum of 85 percent of answers are correct. ______

Overall rating ______

Evaluator's comments ______________________________

____

____

Introduction

Chassis and steering systems on power product equipment have become more complicated over the past few years and are likely to continue to become more complicated for the next several years. There are two main reasons for these developments. First, technology has led to new materials and processes for chassis that are lighter, more durable, and more attractive along with steering systems that are more responsive, require less maintenance, and are safer. Second, consumers expect power product equipment to offer the kinds of conveniences and capabilities they have come to expect in their cars and trucks. Consequently, many chassis and steering systems found on today's power product equipment have tolerance-sensitive specifications and parts that must be carefully selected and applied. In this assignment sheet, you will practice selecting parts and determining specifications for equipment you are likely to service in your career as a power product equipment technician.

Exercise

Directions

Using the resources available in your facility, determine the part numbers and specifications requested in the following questions/items. Write your answers on the blanks provided with each question/item.

Assignment Sheet 1

1. The illustration in Figure 2 on the next page shows the chassis and steering assembly of certain models of Jacobsen riding lawn mowers. Use the numbers in the illustration to answer the following questions.

   a. What is the number of the frame?

   Frame number — ____________________

   b. According to the drawing in Figure 2, is the battery located behind, under, or in front of the seat support? (Circle the correct answer below.)

   Behind   Under   In front of

   c. According to the drawing in Figure 2, the front axle bearing is held together and mounted to the frame by means of four bolts. Two of those bolts also help to mount what other part to the frame?

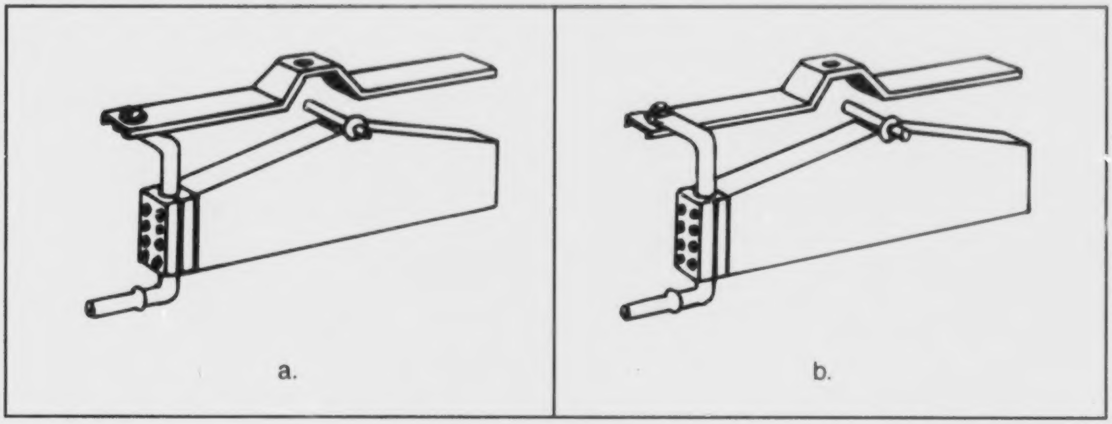
   Part name and number — ____________________

   ____

   d. Which of the drawings in Figure 1 below shows the correct way of assembling the spindle, spindle bearing, front axle, and steering bracket? (Circle the correct answer below.)

   a   b

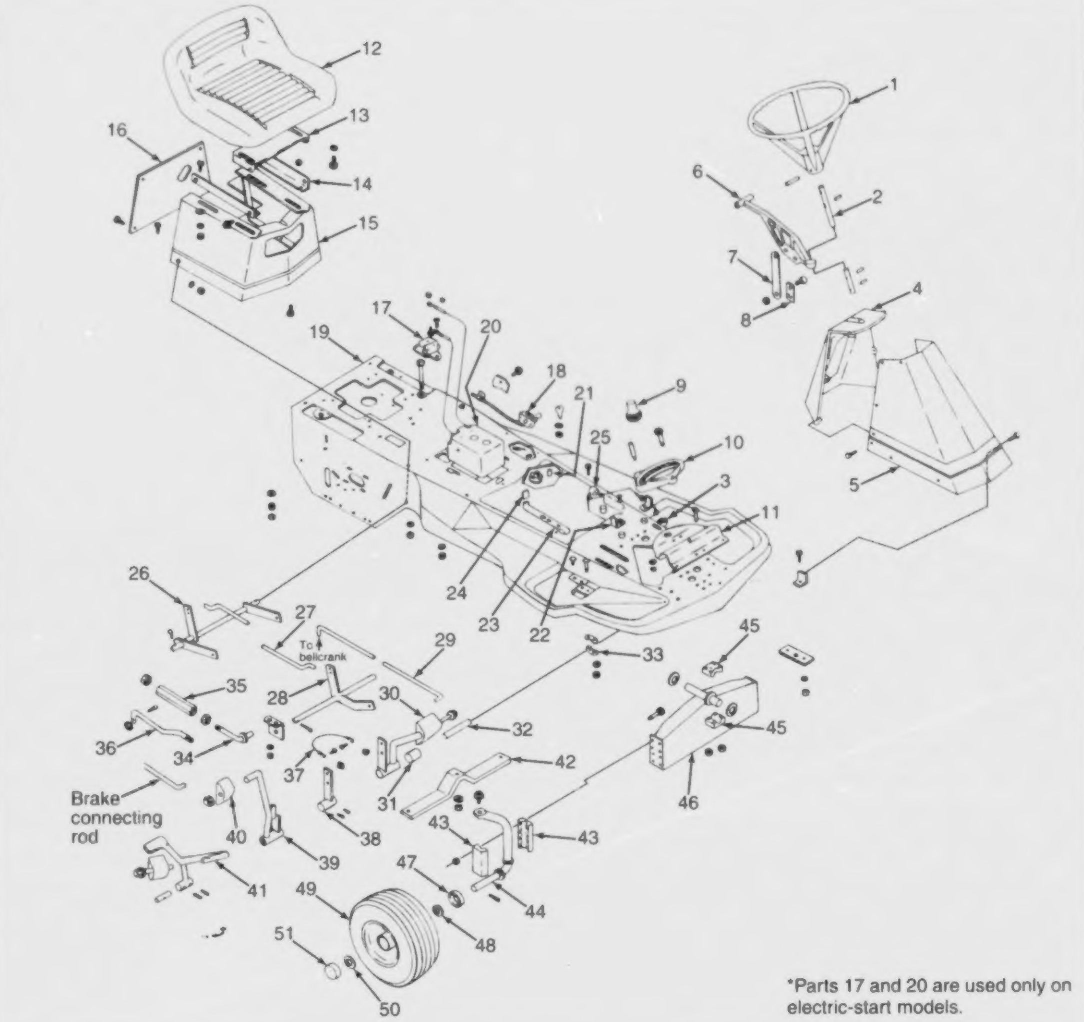
Figure 1



a.   b.

Assignment Sheet 1

Figure 2: Jacobsen chassis diagram (exploded view)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23
22
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To bellcrank
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45
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34
37
42
Brake connecting rod
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31
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51
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50

*Parts 17 and 20 are used only on electric-start models.

1. Steering wheel
2. Steering shaft
3. Bushing
4. Console panel
5. Steering support
6. Lift handle
7. Upper lift link
8. Lower lift link
9. Steering pinion
10. Steering sector
11. Bracket
12. Seat
13. Bracket
14. Seat rail
15. Seat support
16. Reinforcement plate
17. Solenoid*
18. Throttle control
19. Frame
20. Battery*
21. Ignition switch
22. Interlock contact
23. Parking-brake latch
24. Knob
25. Safety module
26. Rear hanger assy.
27. Connecting rod
28. Front hanger assy.
29. Linkage rod
30. Mower pedal
31. Bushing
32. Pivot shaft
33. Shaft bearing
34. Traction rod
35. Turn buckle
36. Traction rod
37. Interlock harness
38. Traction-lever assy.
39. Brake-pedal assy.
40. Brake pedal
41. Forward & reverse pedal
42. Steering bracket
43. Spindle bearing
44. Spindle
45. Front-axle bearing
46. Front-axle assy.
47. Dust washer
48. Washer
49. Wheel assy.
50. Washer
51. Cap

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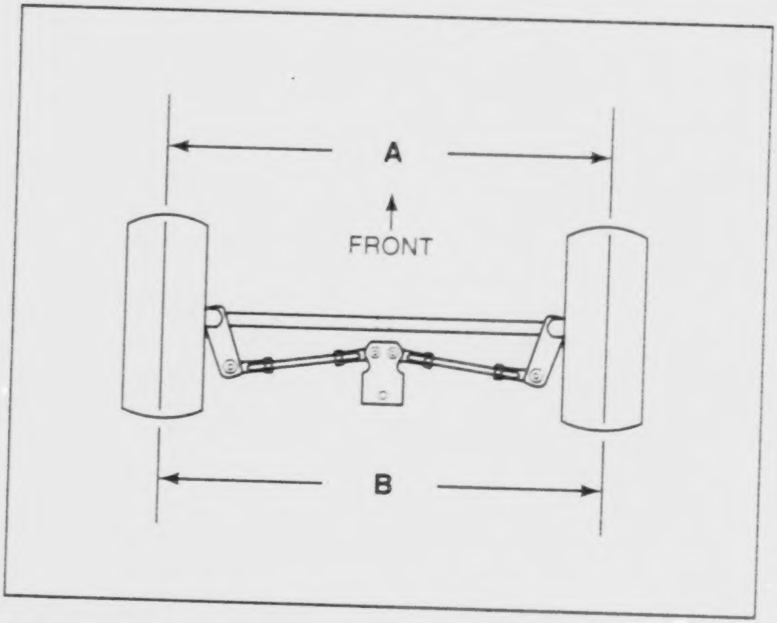
Assignment Sheet 1

2. The illustration in Figure 3 below shows how to make the toe-in adjustment on Case/Ingersoll 8-HP riding lawn mowers. How should Dimensions A and B compare? Be sure to state which dimension is longer.

Figure 3: Toe-in dimensions



Reproduced by permission of Ingersoll Equipment Co., Inc., Winneconne, Wisconsin.

Assignment Sheet 1

3. Figure 4 below shows the location of by-pass valves that are used on some types of power product equipment that use a hydrostatic drive-wheel steering system, as with this Hustler Model 261. What is the purpose of the by-pass valves?

____

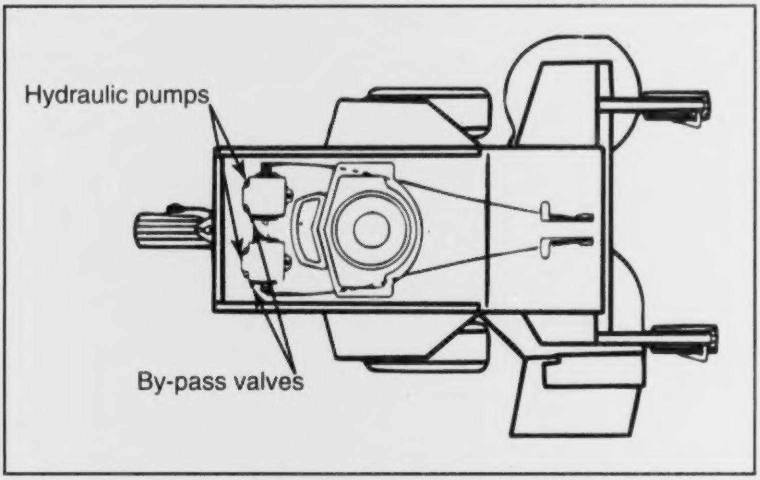
____

____

____

____

Figure 4: Hydrostatic-pump by-pass valve locations



Reproduced by permission of EXCEL INDUSTRIES, Hustler Division, Heston, Kansas.

4. What is the recommended lubricant for the steering-shaft bearings for riding lawn mowers of the following manufacturers?

   a. Sears-Craftsman, 10-HP, 30-inch cut

      Lubricant — ______________________________

   b. John Deere, 11-HP, 30-inch cut

      Lubricant — ______________________________

   c. International Harvester, 8-HP, 32-inch cut

      Lubricant — ______________________________

   d. Snapper, 11-HP, 30-inch cut

      Lubricant — ______________________________

Assignment Sheet 1

e. Ford, 11-HP, 30-inch cut

Lubricant — ____________________

5. The illustration in Figure 5 on the next page shows a typical steering system used on older model Massey-Ferguson riding lawn mowers.

   a. For a Model MF 6, to what length should the drag link be adjusted?

   Length — ____________________

   b. For a Model MF 8, to what length should the drag link be adjusted?

   Length — ____________________

   c. For a Model MF 6, to what length should the tie rod be adjusted?

   Length — ____________________

   d. For a Model MF 8, to what length should the tie rod be adjusted?

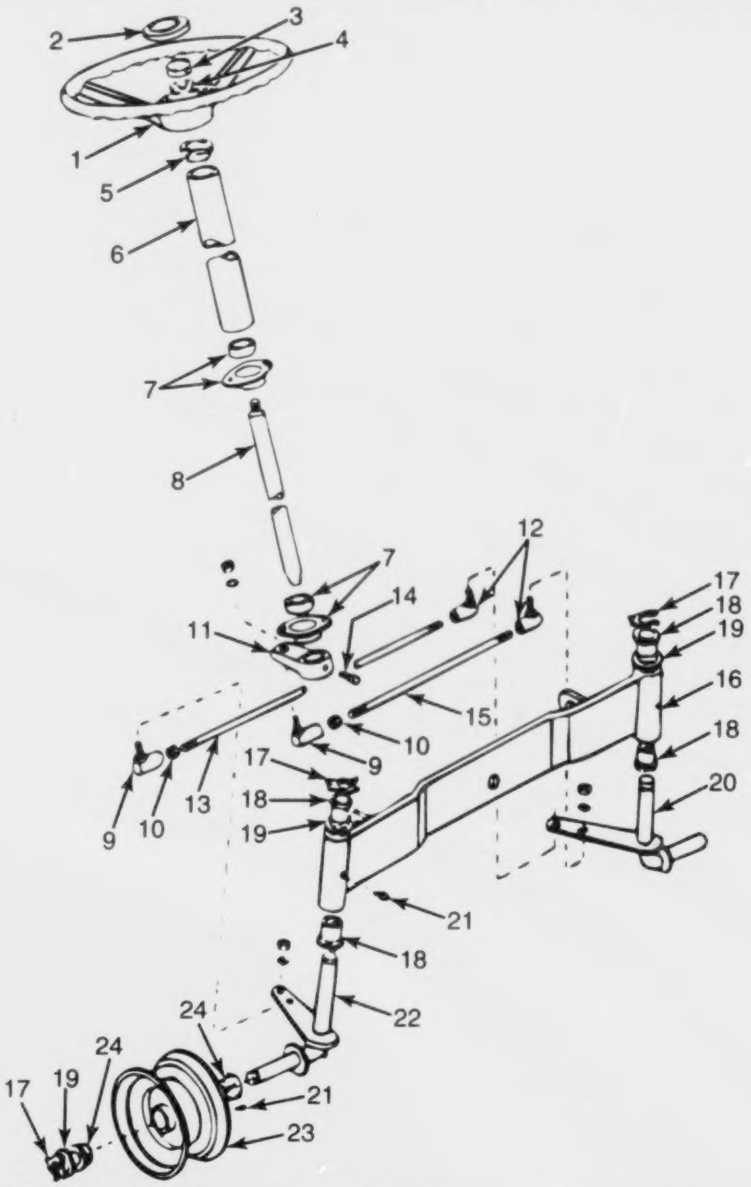
   Length — ____________________

   e. What torque should be used when installing the steering-wheel retainer nut, Item 3 in the drawing?

   Torque — ____________________

Assignment Sheet 1

Figure 5: Massey-Ferguson steering system (exploded view)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1. Steering wheel
2. Cap/logo
3. Nut (⅝ - 18)
4. Washer, flat
5. Washer, special
6. Tube
7. Bushing set (2)
8. Shaft
9. Ball joint (RH thread)
10. Nut (⅜ - 24)
11. Arm
12. Ball joint (LH thread)
13. Tie rod
14. Set screw
15. Drag link
16. Axle assembly
17. "X" lockwasher
18. Spindle bushing (4)
19. Washer (4)
20. Spindle, LH
21. Grease fitting
22. Spindle, RH
23. Wheel & rim
24. Wheel bushing (4)

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Chassis and Steering Systems
Unit 6

Job Sheet 1—Repair or Replace Chassis Components

Introduction

This job sheet covers the procedures associated with repairing and replacing chassis components. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect chassis
- Clean chassis
- Adjust and tighten chassis components
- Replace chassis components
- Remove rust and corrosion
- Remove chassis finishes
- Apply new finishes
- Repair or straighten metal components
- Bore and thread holes

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of repairing and replacing chassis components and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one chassis. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment with a chassis that needs service.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/ materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 1

Worksheet—Repair or Replace Chassis Components

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 1

Worksheet—Repair or Replace Chassis Components

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Chassis and Steering Systems
Unit 6

Job Sheet 2—Perform Routine Maintenance on Mechanical Steering Systems

Introduction

This job sheet covers the routine maintenance associated with mechanical steering systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect mechanical steering components
- Lubricate gears, chains, bearings, and bushings
- Align steering and set toe-in

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of performing routine maintenance on mechanical steering systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one mechanical steering system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a mechanical steering system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/ materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 2

Worksheet—Perform Routine Maintenance on Mechanical Steering Systems

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 2

Worksheet—Perform Routine Maintenance on Mechanical Steering Systems

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Chassis and Steering Systems
Unit 6

Job Sheet 3—Repair Mechanical Steering Systems

Introduction

This job sheet covers the repair procedures associated with mechanical steering systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace mechanical steering components, including gears, shafts, tie-rods, bearings, etc.
- Overhaul mechanical steering subsystems, including gearboxes and steering columns
- Perform adjustments to return equipment to original specifications

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of repairing mechanical steering systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one mechanical steering system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a mechanical steering system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 3

Worksheet—Repair Mechanical Steering Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 3

Worksheet—Repair Mechanical Steering Systems

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

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Chassis and Steering Systems
Unit 6

Job Sheet 4—Perform Routine Maintenance on Hydraulic Steering Systems

Introduction This job sheet covers the routine maintenance associated with hydraulic steering systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect hydraulic steering components
- Check fluid levels
- Adjust belt tension
- Align pulleys and shafts

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of performing routine maintenance on hydraulic steering systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one hydraulic steering system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a hydraulic steering system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 4

Worksheet—Perform Routine Maintenance on Hydraulic Steering Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 4

Worksheet—Perform Routine Maintenance on Hydraulic Steering Systems

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Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ______________________________

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Chassis and Steering Systems
Unit 6

Job Sheet 5—Repair Hydraulic Steering Systems

Introduction

This job sheet covers the repair procedures associated with hydraulic steering systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace hydraulic steering components, including gears, belts, seals, etc.
- Overhaul hydraulic steering subsystems, including gearboxes and pulley systems
- Perform adjustments to return equipment to original specifications

Note: You may use this job sheet for either hydraulic-assisted steering systems or hydrostatic systems.

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of repairing hydraulic steering systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one hydraulic steering system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a hydraulic steering system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 5

Worksheet—Repair Hydraulic Steering Systems

Name ______________________ Attempt number ________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 5

Worksheet—Repair Hydraulic Steering Systems

Part B: Performance evaluation

Evaluation criteria	Rating
Correct procedures identified for assigned equipment.	________
Procedures completed correctly.	________
Proper tools used correctly.	________
Safety precautions observed.	________
Service meets specifications.	________
Clean-up and follow-up actions adequate.	________
Overall rating	________

Evaluator's comments ____

____

____

Chassis and Steering Systems
Unit 6

Job Sheet 6—Perform Routine Maintenance on Drive-Wheel Steering Systems

Introduction

This job sheet covers the routine maintenance associated with drive-wheel steering systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect steering components
- Check linkages
- Adjust belt tension
- Align pulleys and shafts

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of performing routine maintenance on drive-wheel steering systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one drive-wheel steering system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a drive-wheel steering system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 6

Worksheet—Perform Routine Maintenance on Drive-Wheel Steering Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 6

Worksheet—Perform Routine Maintenance on Drive-Wheel Steering Systems

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Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	________
Procedures completed correctly.	________
Proper tools used correctly.	________
Safety precautions observed.	________
Service meets specifications.	________
Clean-up and follow-up actions adequate.	________
Overall rating	________

Evaluator's comments ____

____

____

Chassis and Steering Systems
Unit 6

Job Sheet 7—Repair Drive-Wheel Steering Systems

Introduction

This job sheet covers the repair procedure associated with drive-wheel steering systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace steering components, including gears, belts, seals, etc.
- Overhaul steering subsystems, including gearboxes and pulley systems
- Perform adjustments to return equipment to original specifications

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1.

2. Watch your instructor's demonstration of repairing drive-wheel steering systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one drive-wheel steering system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a drive-wheel steering system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 7

Worksheet—Repair Drive-Wheel Steering Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 7

Worksheet—Repair Drive-Wheel Steering Systems

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Chassis Electrical Systems
Unit 7

Objective Sheet

Unit objective

After completing this unit, the student should be able to describe the design and operation of chassis electrical systems and perform routine maintenance and service procedures on such systems. The student should demonstrate these competencies by completing the assignment sheets and job sheets and by scoring a minimum of 85 percent on the written test.

Specific objectives

After completing this unit, the student should be able to

1. Match terms associated with electrical systems to their correct definitions.
2. State the functions of the major components of chassis electrical systems.
3. State the functions of the types of safety shutoff devices used in chassis electrical systems.
4. Match types of personal-safety shutoff devices to their correct functions.
5. Match types of equipment-safety shutoff devices to their correct functions.
6. Describe the types of lights used in chassis electrical systems.
7. List typical service procedures required for chassis electrical systems.
8. Complete statements about the principles of operation of electric equipment drives.
9. List typical service procedures required for electric equipment drives.
10. Identify the major components of electromagnetic clutches.
11. Complete statements about the principles of operation of electromagnetic clutches.
12. List typical service procedures required for electromagnetic clutches.
13. Label common symbols used on electrical schematics.
14. State functions of the specialty instruments used in electrical-system repair.
15. Interpret chassis-electrical-system schematics. (Assignment Sheet 1)
16. Determine chassis-electrical-system service specifications and parts requirements. (Assignment Sheet 2)
17. Perform routine maintenance on chassis electrical systems. (Job Sheet 1)
18. Repair chassis electrical systems. (Job Sheet 2)

Objective Sheet

19. Perform routine maintenance on electrical equipment drives. (Job Sheet 3)

20. Repair electrical equipment drives. (Job Sheet 4)

21. Perform routine maintenance on electromagnetic clutches. (Job Sheet 5)

22. Repair electromagnetic clutches. (Job Sheet 6)

Chassis Electrical Systems
Unit 7

Information Sheet

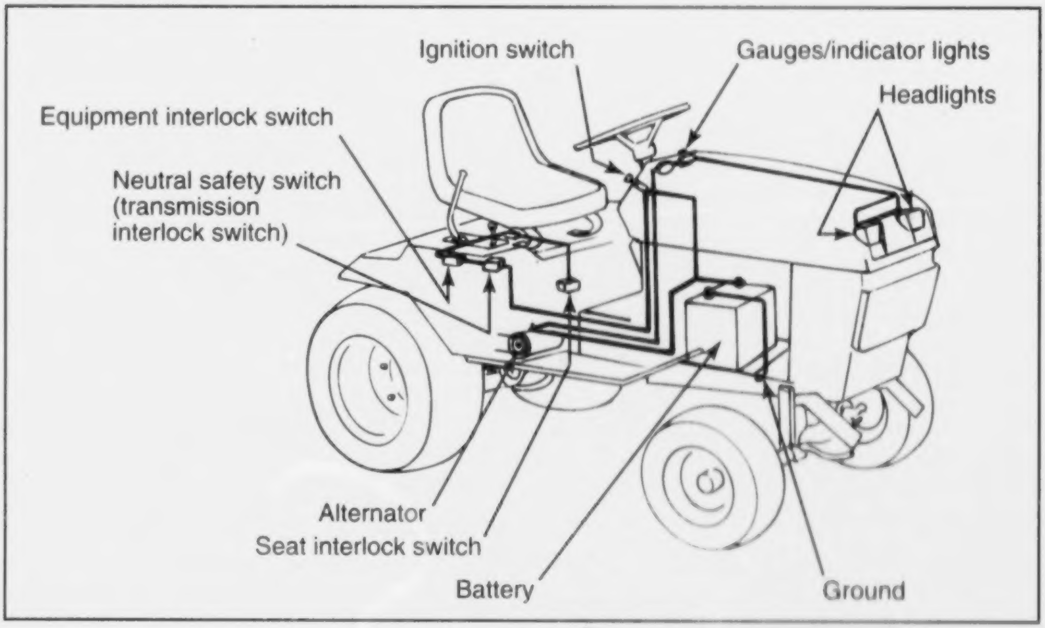
1. **Terms and definitions associated with electrical systems**

Note: Power product equipment is generally considered to have two electrical systems or subsystems. You are already familiar with the use of electricity in the ignition of the fuel/air mixture in the internal-combustion engine and in other engine-related functions, such as electrical starters and charging systems. Many types of power product equipment—especially operator-ridden equipment—use electricity in other applications. The non-engine applications are generally referred to as *chassis electrical systems*. Most of the terms below apply to both engine and chassis electrical systems and should be familiar to you. If you do not recognize or remember these terms, you should review basic electrical concepts presented in *Engine Systems and Service, Section A: Engine Systems*, "Unit 5, Basic Electrical Principles."

- **Ampere**—Unit of measure for the rate of electrical flow
- **Continuity**—Ability of a system to support electrical flow as a complete circuit
- **Current**—Rate of electrical flow
- **Electromotive force**—Force that causes electrical flow
- **Ohm**—Unit of measure for resistance to electrical flow
- **Resistance**—Opposition of a substance to electrical flow
- **Volt**—Unit of measure for the amount of electromotive force in an electrical current

2. **Major components of chassis electrical systems and their functions** (see Figure 1)

Figure 1: Major components of chassis electrical systems


Ignition switch
Gauges/indicator lights
Headlights
Equipment interlock switch
Neutral safety switch (transmission interlock switch)
Alternator
Seat interlock switch
Battery
Ground

- **Equipment interlock switch**—Prevents the engine from starting if the equipment drives are engaged

  Note: Equipment interlock switches interrupt the starter circuit when equipment drives are engaged so that the starter will not have to strain against the additional load and to avoid accidents if the operator is unaware that the equipment is engaged.

- **Neutral safety switch** (transmission interlock switch)—Prevents the engine from starting if the transmission is not in *park* or *neutral*

  Note: A common accident before neutral safety switches was an operator being thrown from a vehicle or a vehicle rolling off jacks when started in gear. When the transmission is engaged, an electric starter will drive the engine, which will drive the transmission and the drive wheels. The neutral safety switch keeps the engine from starting if the transmission is in a drive gear.

- **Ignition switch**—Allows the operator to direct or shut off electricity to the starter or ignition system

  Note: Most types of power product equipment with electric starters have a three-position ignition switch: off, start, and run. In the *off* position, the electrical circuit is broken. With the switch in the *start* position, electricity flows from the battery to the starter. Most ignition switches automatically return to the *run* position once released from *start*. In the *run* position, the electrical circuit for the alternator is closed, providing engine ignition, battery charging, and operation of other devices such as headlights. Some types of equipment have a four-position switch, the fourth position providing for headlight operation.

- **Gauges/indicator lights**—Provide the operator with information about the functioning of some equipment systems

  Note: Gauges and indicator lights are installed on some types of equipment to provide the operator with information about the status of certain systems. The most common systems monitored are fuel, lubrication, cooling, and charging. Gauges may be provided to show the amount of fuel in the tank, oil pressure, the temperature of coolant, and the amperage or voltage output of the alternator. Indicator lights may be used for warning the operator of low oil pressure, high temperature, or low charging output from the alternator. Some types of equipment have a warning light that indicates a failure in the hydraulic brake system.

- **Headlights**—Provide illumination in front of the equipment

  Note: Headlights (headlamps) are common on riding lawn mowers, tractors, motorcycles, snowmobiles, and other power product equipment vehicles. Some vehicles may also have taillights, brake lights, and lights on the side called *running lights*.

- **Alternator**—Generates electricity to recharge the battery and to operate other systems

  Note: Electrical circuits on power product equipment operate on power from the battery or from the alternator. A general rule is that those systems (such as the starter) that must work without the engine running receive power from the battery while all other systems receive power from the alternator.

Information Sheet

- **Seat interlock switch**—Prevents the engine from starting or running if there is no weight on the seat

  Note: Numerous accidents have occurred when operators have left the engine running and gotten off the equipment to change attachments, open gates, or do other tasks. Vehicles have rolled over the operators, and operators and other people have been injured by blades, discharged objects, and equipment drives. In other cases, operators have fallen off a vehicle only to have the vehicle wreck or cause injury as it continues to operate. Today, most equipment will not run if the driver gets off the seat. In some cases, the engine will run if the transmission is in the *park* position and the equipment drive is not engaged.

- **Ground**—Provides the electrical path to form complete circuits

  Note: For most types of equipment, the chassis and the frame serve as the ground for the chassis electrical system, and the negative cable of the battery and the negative side of the chassis electrical system connect to the ground. In some older systems, a positive ground is used.

- **Battery**—Provides electricity for some chassis electrical components

  Note: The batteries for most types of power product equipment are used primarily in the engine electrical system to power the electric starter motor. Most chassis electrical-system components are powered by the alternator. However, with applications where it is important to provide power while the engine is not operating, battery power may be used. For example, the running lights of an outboard-engine boat may operate on battery power with the engine off.

3. **Types of safety shutoff devices used in chassis electrical systems and their functions**

   Note: Equipment manufacturers want to protect the equipment from damage and the operator from injury. For these reasons, manufacturers equip their products with numerous safety devices, including shutoff devices and warning systems. The majority of these devices operate on electricity, which may be used to power a sensor or a warning device. Many of these devices are electrical switches that are installed in the ignition or starting system and interrupt the flow of electricity if a safety or operational hazard exists. Because they tie systems together, these switches are also referred to as *safety interlock switches*.

   - **Personal-safety shutoff devices**—Stop the operation or movement of the equipment to protect the operator or other people in the immediate area

   - **Equipment-safety shutoff devices**—Stop or limit the operation of the equipment to prevent damage to the equipment

4. **Types of personal-safety shutoff devices and their functions**

   Note: Equipment manufacturers go to great lengths to make their equipment safe, and research shows that personal-safety devices are effective in preventing injuries to operators when the devices are left functional on properly operated equipment. The following list describes the more common types of personal-safety shutoff devices used on power product equipment. It is unlikely that you will find all of these devices on a single piece of equipment.

Information Sheet

- **Clutch switch**—Prevents the engine from starting when the equipment drive or drive-train clutch is engaged

  Note: Power product equipment may have several clutch switches, including switches for the transmission clutches, equipment drive-belt clutches, PTO clutches, etc. Such switches provide personal protection because numerous accidents have resulted in the past from operators' starting equipment with drives engaged. If the drive train is engaged, the vehicle may bolt forward, which could throw the operator from the vehicle or cause the equipment to run into a bystander. If equipment drives start with the engine, an operator or assistant may have hands, feet, or body parts in the way of blades, gears, chains, belts, or other mechanisms that they did not expect to operate. Safety devices have helped to reduce these types of accidents.

- **Seat interlock switch**—Shuts down the engine or equipment drives when there is no pressure on the seat

  Note: There are many variations in seat interlock switch designs. Some seat switches are connected to sensors in the equipment-drive and drive-train systems so that the engine will operate if the drive-train transmission is in *neutral* or *park* and no equipment drives are engaged.

- **Flywheel brake**—Stops the engine and blade rotation upon release of a control handle

- **Blade brake**—Stops the rotation of the blade without stopping the engine upon release of a control handle

  Note: Walk-behind rotary mowers built after June 30, 1982, are equipped with a control handle that must be engaged for the blade to turn and that are spring-loaded to disengage. In most designs, the operator must hold the handle engaged. By regulation, the blade must stop within 3 seconds once the handle is released. Both flywheel brakes and blade brakes are used to meet the requirements of this legislation.

- **Back-up switch**—Shuts down the equipment if the blades or other specific devices are in operation when the transmission/transaxle is shifted into reverse

  Note: Some types of equipment, such as fork lifts and other industrial power product vehicles, produce an audible alarm when the equipment is operated in reverse.

- **Neutral safety switch**—Prevents the engine from starting if the equipment is not configured in a certain way, such as having the transmission in *neutral* or *park*

  Note: Neutral safety configurations may also require that blades or other devices be disengaged. Some mechanical drive-train equipment will allow starting if the clutch is disengaged from the engine.

- **PTO-off switch**—Prevents the engine from starting when the PTO is engaged

- **Shield switch**—Prevents the engine from starting or operating if protective shields are not in place

  Note: Equipment with sharp or powerful moving parts, such as mulchers and log splitters, often have mechanical shields or doors that protect the operator from dangerous parts. Some mowers that accept bags to collect grass cuttings have a shield that goes over the discharge chute. Often the equipment will not start or operate unless the shield is in place.

Information Sheet

- **Tilt switch**—Prevents the engine from running when the equipment exceeds a specified angle with respect to horizontal

  Note: Mowers, all-terrain vehicles, garden tractors, snowmobiles, and other types of equipment are likely to travel across the face of an incline, such as a hill or embankment, or to travel up very steep inclines. When traveling across an incline, the equipment will roll over once the majority of the weight of the operator and equipment are farther from the incline than from the center of gravity. When going up hill, the rear wheels act as a pivot point and the equipment will roll over backwards once there is more weight behind a vertical line through the center of the rear wheels than is ahead of the imaginary vertical line.

5. **Types of equipment-safety shutoff devices and their functions**

Note: Power product equipment may include switches to protect the equipment. For simplicity and low cost, these devices often work automatically rather than by providing a warning to the operator and allowing the operator to make a response to the condition.

- **Oil-pressure switch**—Shuts down the equipment when the lubrication-system pressure drops below a specific reading

- **Oil-level switch**—Shuts down the equipment when the oil level in the lubrication-system reservoir drops below a specific level

  Note: Some types of equipment have indicators that provide the operator with information about oil pressure or level. These indicators are normally warning lights or gauges.

- **Temperature switch**—Shuts down the equipment when a monitored temperature, such as coolant or oil temperature, exceeds a specific limit

- **Tilt switch**—Shuts down the equipment when the equipment exceeds a specified angle with respect to horizontal

  Note: Most lubrication systems use pumps or slingers to drench moving engine parts with oil. However, if there is insufficient oil in contact with the pump intake or slinger due to excessive tilt, lubrication will not be adequate. Further, fuel tanks must be vented and many types of power product equipment engines use gravity-feed carburetors that will not operate beyond certain angles that would represent the danger of a fuel spill.

- **RPM limiter**—Prevents the engine speed from exceeding a specific rate

  Note: The RPM limiter is sometimes referred to as an *overspeed switch*. Some types of equipment provide a gauge called a *tachometer* to indicate engine speed or an engine-overspeed warning light.

- **Fuel shutoff**—Prevents the flow of fuel when the engine is not running

  Note: Many types of power product equipment include manual switches to shut off fuel. These manual switches are designed primarily to prevent spillage when the equipment is transported and to relieve pressure on the fuel-bowl float when the equipment is stored.

6. Types of lights used in chassis electrical systems and their descriptions

- **Alternating-current lights**—Lights that receive their power from the alternator and will not operate unless the engine is running

  Example: Headlights on many riding lawn mowers

- **Direct-current lights**—Lights that receive their power from the battery and will operate whether or not the engine is running

  Example: Brake lights

7. Typical service procedures required for chassis electrical systems

- Measure electrical characteristics such as voltage, voltage-drop, and resistance
- Remove and replace electrical components
- Adjust alternator-belt tension
- Charge battery
- Replace bulbs
- Repair wiring and electrical coils

8. Principles of operation of electric equipment drives

Note: An electrical equipment drive functions just like other types of equipment drives except that the source of power is an electric motor. The electric motor, in turn, is driven by an alternator or battery. The motor's output shaft is usually equipped with a pulley or sprocket to drive a belt or chain, respectively. In a typical application, electricity from a garden tractor's chassis electrical system will be connected to electric motors that power the blades of a mower deck.

- An electrical switch is provided to allow the operator to turn the equipment on or off.
- Electricity from the alternator or battery is routed to an electric motor.
- The electric motor powers the equipment directly or powers a transmission that transfers the force to the equipment.

9. Typical service procedures required for electric equipment drives

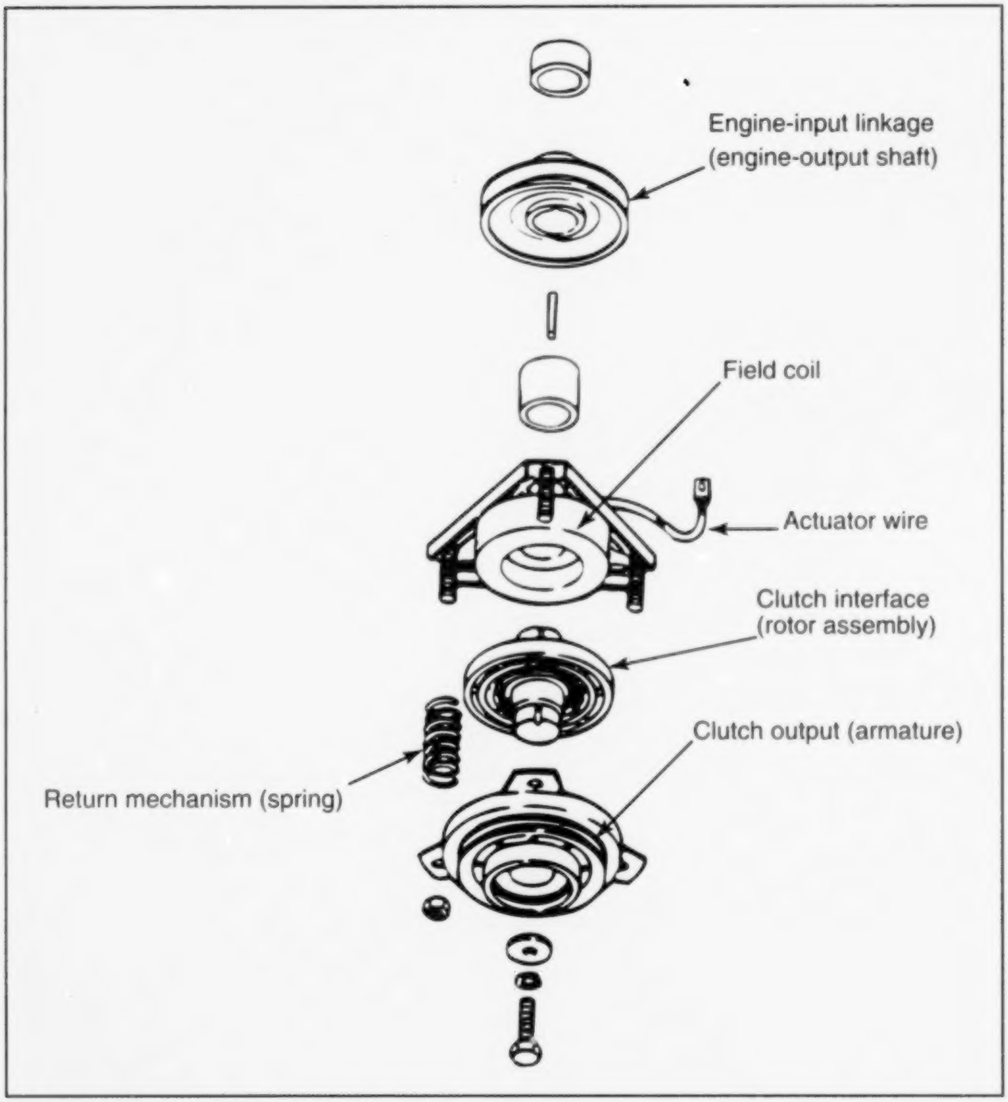
- Measure circuit electrical characteristics such as voltage and resistance
- Remove and replace electrical components
- Adjust alternator-belt tension
- Repair wiring and electrical coils

Information Sheet

10. Major components of electromagnetic clutches (see Figure 2)

Note: Figure 2 shows a typical electromagnetic clutch. This type of clutch is used primarily for equipment drives. It can be an effective clutch but requires a source of electricity. The electricity creates a magnetic field using the same principles that you studied as applicable to electric starters and alternators, where a metal core in a wire coil becomes magnetic when a current is applied. The components labeled are comparable to those in other clutch systems presented in Unit 2 and Unit 4. For example, you should be able to recognize the actuator (switch), engine-input linkage (engine-output shaft), clutch interface (rotor assembly), clutch output (armature), and return mechanism (spring).

Figure 2: Major components of electromagnetic clutches


Engine-input linkage
(engine-output shaft)
Field coil
Actuator wire
Clutch interface
(rotor assembly)
Clutch output (armature)
Return mechanism (spring)

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Information Sheet

11. **Principles of operation of electromagnetic clutches** (see Figure 2 on page 327)

- The rotor assembly is mounted to the end of the engine crankshaft.
- The armature is mounted to the end of the transmission or equipment-drive shaft.
- With the engine running and the clutch engaged, an electromagnetic field is generated in the field coil and rotor assembly.
- The magnetic field holds the armature and clutch output to the rotor assembly, allowing power to be transferred from the engine.
- When the clutch pedal is depressed, the flow of electricity to the field coil is disrupted, causing the electromagnetic field to collapse.
- Centrifugal force or spring tension separates the rotor assembly and the armature.
- When the clutch pedal is released, the electromagnetic field is restored, causing the armature to be held to the rotor assembly.

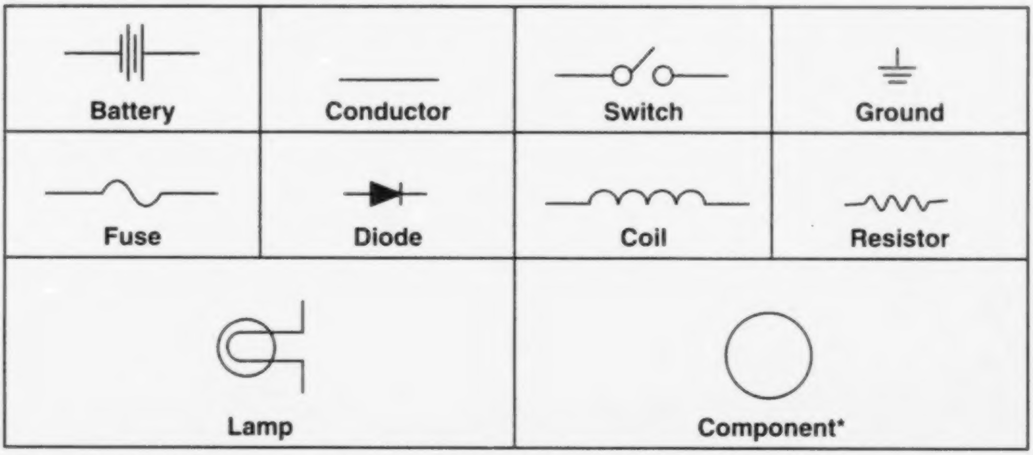
12. **Typical service procedures required for electromagnetic clutches**

- Measure circuit electrical characteristics such as voltage and resistance
- Remove and replace electrical components
- Adjust alternator-belt tension or engine-belt tension
- Repair wiring and electrical coils

13. **Common symbols used on electrical schematics**

Note: You should be familiar with most of these symbols from your studies of engine electrical systems. The symbols included here are those most commonly used with chassis electrical systems.

Figure 3: Common symbols used on electrical schematics



*Many electrical components are shown as a circle with a symbol or abbreviation inside the circle.

Information Sheet

14. Specialty instruments used in electrical-system repair and their functions

Note: The instruments listed below are the same instruments you have used to troubleshoot and repair engine electrical systems. In addition to the tools used to measure electrical characteristics, some types of power product equipment include instruments on the equipment that measure electrical characteristics, such as ammeters that show the rate of battery charging.

- **Continuity light**—Indicates whether current is present

  Note: Continuity lights are useful in determining whether current is available at a point in a circuit. Continuity lights are very useful in power product equipment to verify operation of safety switches because they can be used to bypass a switch or other component to see if the circuit will work if that component is not part of the circuit.

- **Multimeter**—Measures voltage, current, or resistance

  Note: Multimeters provide the capabilities of a voltmeter, ammeter, and ohmmeter and can be used to measure any electrical characteristic. Because of their versatility and convenience, multimeters are the electrical instrument of choice for many power product equipment technicians.

- **Voltmeter**—Measures voltage

  Note: Voltmeters are most commonly used to verify battery output and to check voltages after loads.

- **Ammeter**—Measures current

  Note: Ammeters are often used to check electronic components and to check the charging circuit.

- **Ohmmeter**—Measures resistance

  Note: Resistance measurement is useful in determining whether wiring and components are as conductive as they should be. Breaks in the wiring, corrosion, loose connections, defective components, and other conditions may lead to high resistance and electrical problems.

Chassis Electrical Systems
Unit 7

Assignment Sheet 1—Interpret Chassis-Electrical-System Schematics

Name ______________________________ Date ______________

Evaluation criteria **Rating**

Directions have been followed. ______

Minimum of 85 percent of answers are correct. ______

Overall rating ______

Evaluator's comments ______________________________

____

____

Introduction Internal-combustion engines use electrical systems to support ignition and often to provide electrical starting. Additionally, many types of power product equipment often have other electrical systems for lights, gauges, and safety devices. Some types of power product equipment use electrical systems in place of certain normally mechanical systems, such as electrical blade motors, lift equipment, etc. The use of electrical subsystems is likely to increase as the types of power product equipment continue to become more sophisticated, making it even more critical that a technician be able to service and repair electrical systems. A key skill in being able to provide electrical troubleshooting, repair, and service is the ability to interpret the schematics that describe power product equipment electrical systems. In this assignment sheet, you will practice selecting parts and determining specifications for equipment that you are likely to service in your career as a power product equipment technician.

Exercise

Directions Using resources available in your facility, determine the part numbers and specifications requested in the following questions. Write your answers on the blanks provided with each question, or follow the specific directions with the question.

Assignment Sheet 1

1. Figure 1 on the next page shows the electrical schematic for certain models of John Deere riding lawn mowers.

   a. The red wire from the ignition switch goes to what component?

      Component — ____________________

   b. What types of safety-start switches are found on this equipment?

      Safety-start switches — ____________________

      ____

   c. The positive pole of the battery is connected to the ignition switch by what color of wire?

      Wire color — ____________________

   d. Is the following statement true or false? The two green wires for the safety-start switch on the recoil starter connect to the mower clutch safety-start switch and the engine terminal. (Circle the correct answer below.)

      True False

   e. How can the starter operate if only one wire is shown going to the starter from the ignition switch?

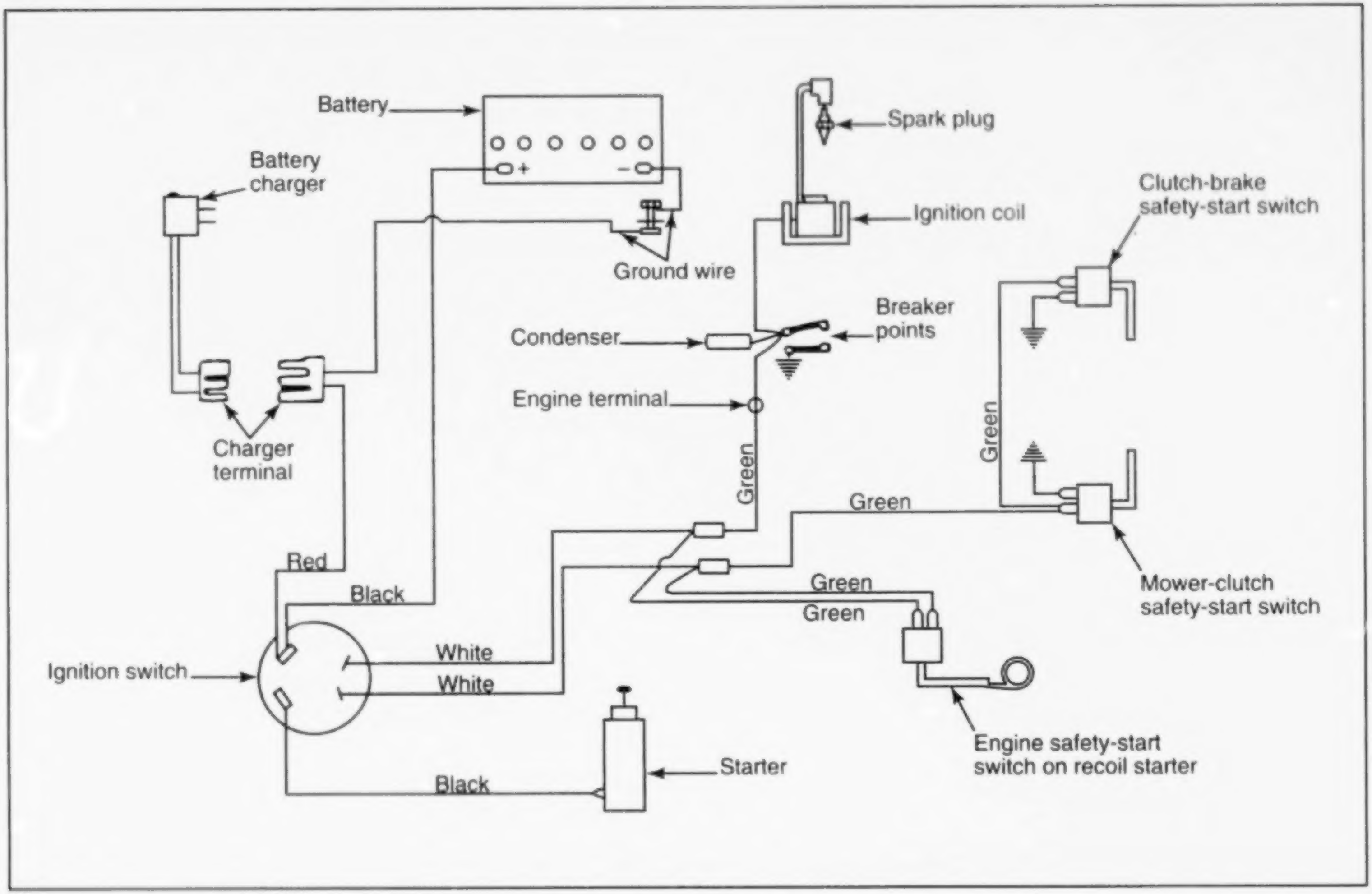
      ____

      ____

      ____

      ____

Figure 1: John Deere electrical schematic


Battery
Battery charger
Spark plug
Ignition coil
Clutch-brake safety-start switch
Ground wire
Breaker points
Condenser
Engine terminal
Charger terminal
Green
Green
Green
Red
Black
Green
Green
Mower-clutch safety-start switch
Ignition switch
White
White
Starter
Black
Engine safety-start switch on recoil starter
+
−

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Assignment Sheet 1

2. Gilson front-engine tractors typically use electrical systems such as the one shown in Figure 2 on the next page.

   a. Will headlights operate if the fuse between the solenoid and the ignition switch is blown? (Circle the correct answer below.)

      Yes No

   b. Will the PTO operate if the clutch-brake microswitch is open? (Circle the correct answer below.)

      Yes No

   c. What color of wire connects the solenoid to the starter?

      Wire color — ______________________

   d. Is the following statement true or false? Both the negative and positive poles of the battery use the same color of wire. (Circle the correct answer below.)

      True False

   e. Are the headlights wired in series or in parallel? How do you know?

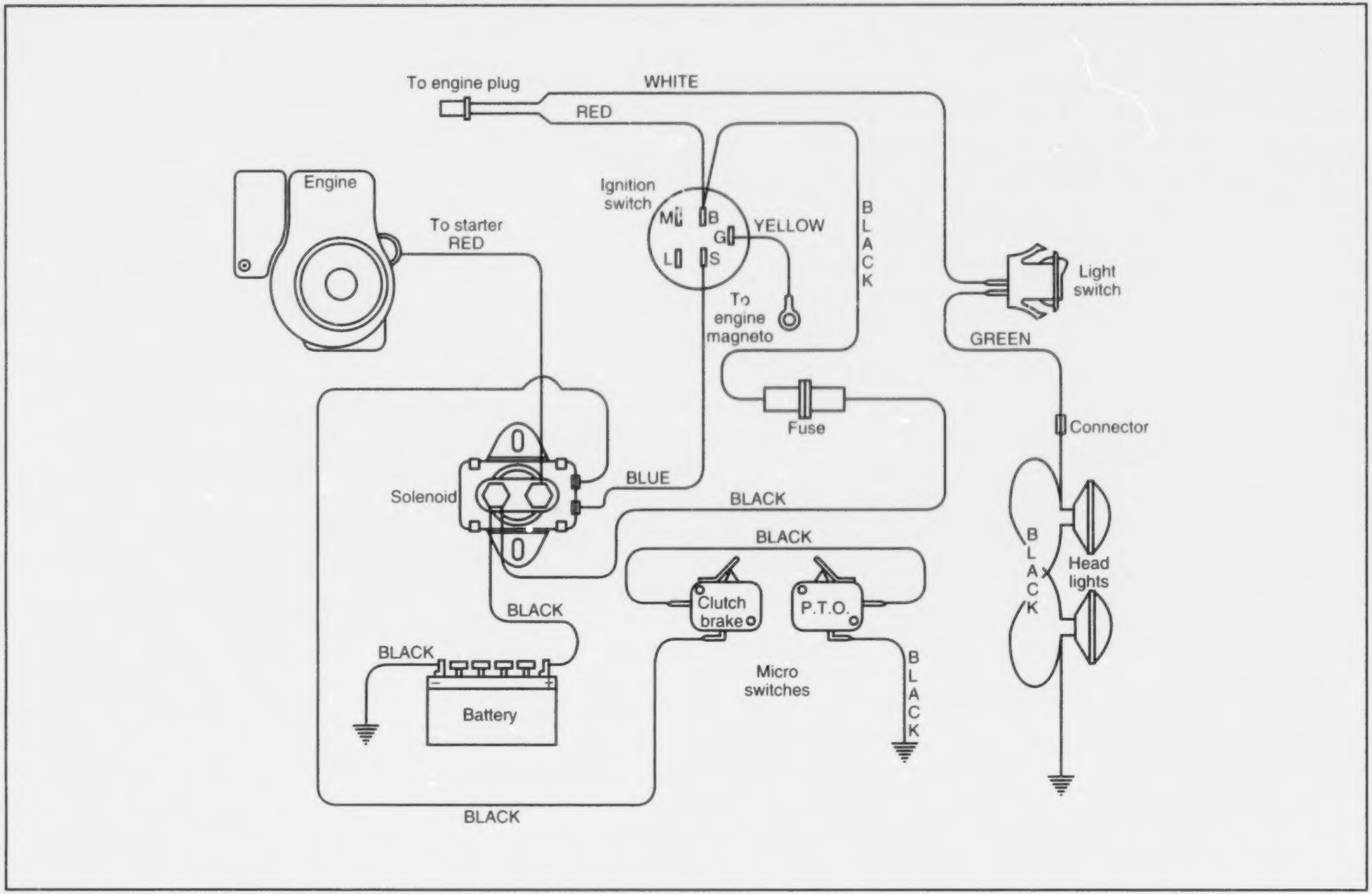
      ____

      ____

      ____

      ____

Figure 2: Gilson tractor electrical schematic


To engine plug
WHITE
RED
Engine
To starter
RED
Ignition
switch
M
B
G
YELLOW
L
S
To
engine
magneto
BLACK
Light
switch
GREEN
Fuse
Connector
Solenoid
BLUE
BLACK
BLACK
BLACK
Head
lights
Clutch
brake
P.T.O.
BLACK
BLACK
Battery
Micro
switches
BLACK
BLACK

Reproduced by permission of The Toro Company, Bloomington, Minnesota.

Assignment Sheet 1

3. Figure 3 on the next page shows a typical wiring diagram for some models of Massey-Ferguson riding lawn mowers.

   a. What color of wire is used with the seat safety interlock switch?

   Wire color — ____________________

   b. What is the amperage of the fuse between the ignition switch and the solenoid?

   Fuse amperage — ____________________

   c. What gauge of wire connects the ignition switch to engine magneto?

   Wire gauge — ____________________

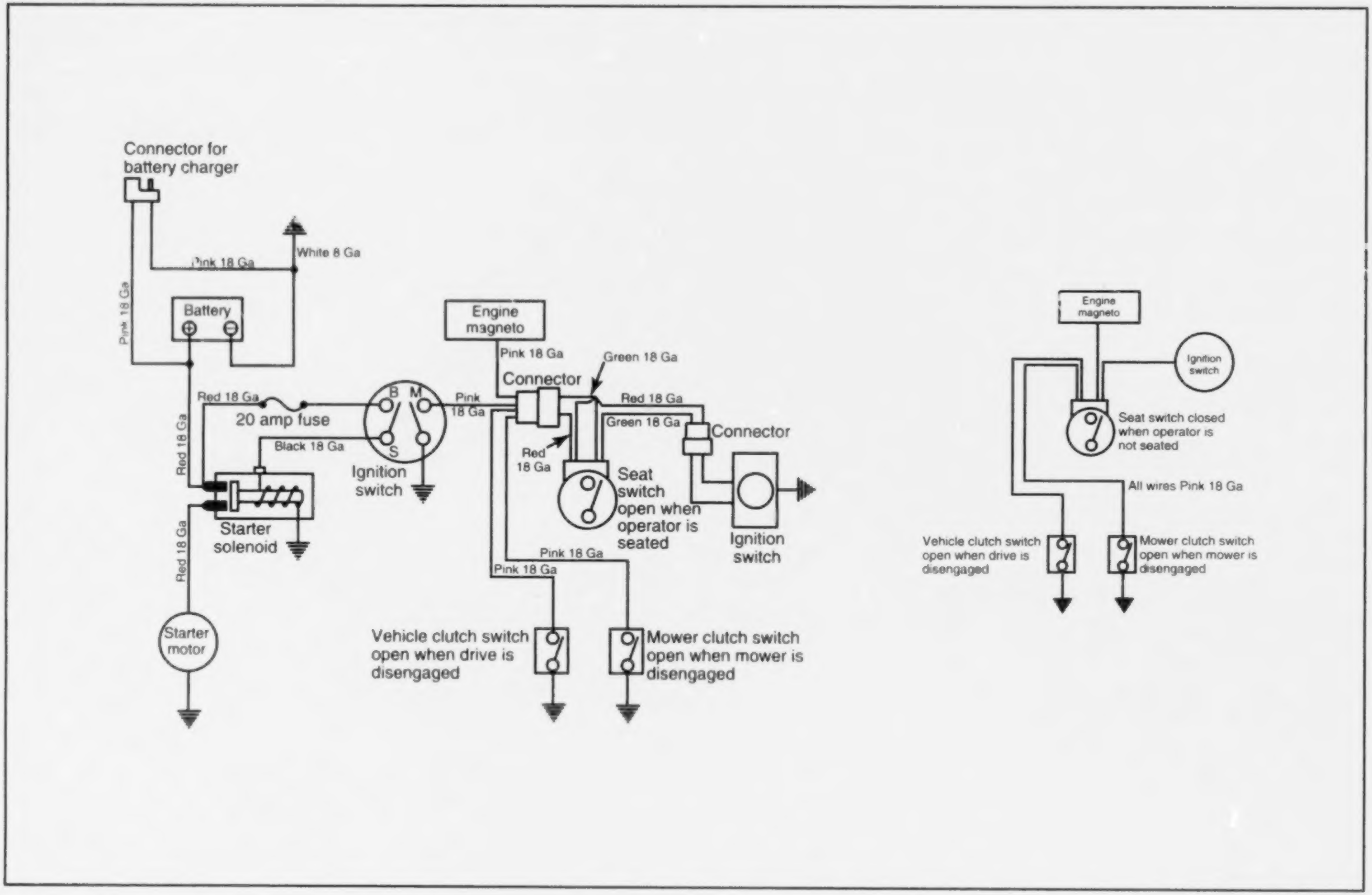
   d. Is the following statement true or false? The interlock switches are all on the ignition side of the ignition switch; therefore, the starter will operate even if the interlock switches are open. (Circle the correct answer below.)

   True False

   e. Can the battery charger function properly if the ignition switch is open? (Circle the correct answer below.)

   Yes No

Figure 3: Massey-Ferguson electrical schematic


Connector for battery charger
White 8 Ga
Pink 18 Ga
Pink 18 Ga
Battery
Red 18 Ga
20 amp fuse
Black 18 Ga
B
M
S
Ignition switch
Red 18 Ga
Starter solenoid
Red 18 Ga
Starter motor
Engine magneto
Pink 18 Ga
Connector
Green 18 Ga
Pink 18 Ga
Red 18 Ga
Green 18 Ga
Red 18 Ga
Connector
Seat switch open when operator is seated
Ignition switch
Pink 18 Ga
Pink 18 Ga
Vehicle clutch switch open when drive is disengaged
Mower clutch switch open when mower is disengaged
Engine magneto
Ignition switch
Seat switch closed when operator is not seated
All wires Pink 18 Ga
Vehicle clutch switch open when drive is disengaged
Mower clutch switch open when mower is disengaged

Reproduced by permission of Massey-Ferguson, Inc., Des Moines, Iowa.

Assignment Sheet 1

4. The wiring schematic for a Hustler Model 295 riding lawn mower is shown in Figure 4 on the next page.

   a. What color of wire is used to connect the battery to the engine ground?

   Wire color — ______________________________

   b. The equipment includes a number of warning lights. Are these lights powered by the battery or the alternator? (Circle the correct answer below.)

   Battery Alternator

   c. To which terminal of the ignition switch is the hour meter connected?

   Terminal — ______________________________

   d. Is the following statement true or false? The electric clutch will not work if the neutral lock switch is not closed. (Circle the correct answer below.)

   True False

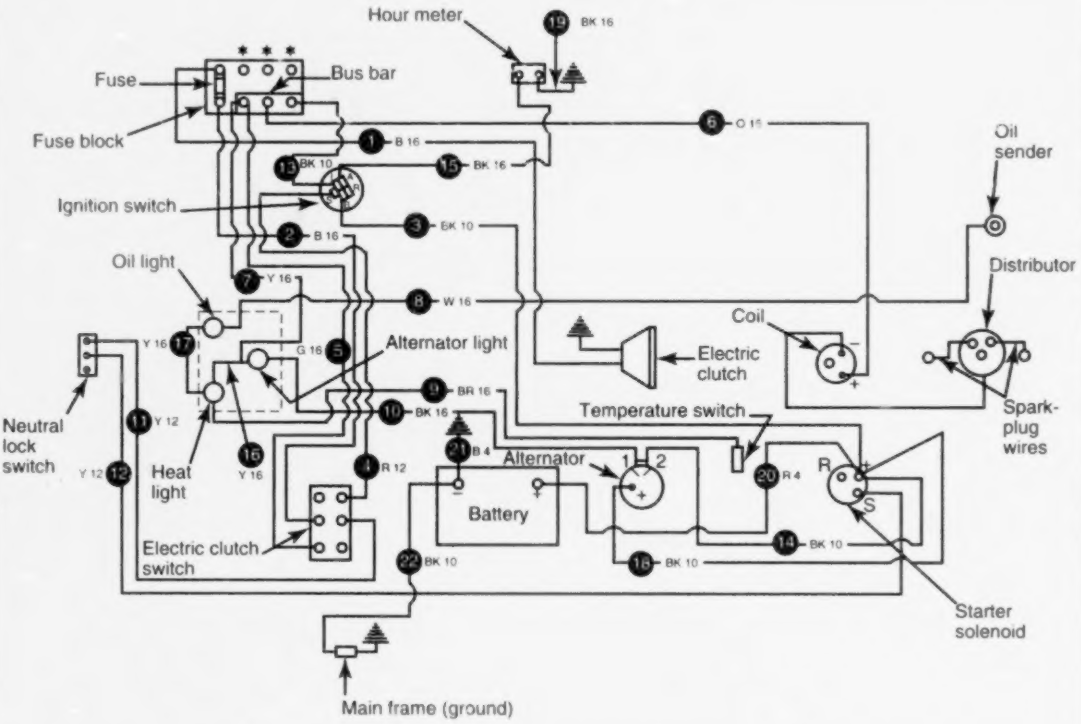
   e. What gauge and color of wire connect the starter solenoid to the neutral lock switch?

   Wire gauge — ______________________________

   Wire color — ______________________________

Assignment Sheet 1

Figure 4: Hustler electrical schematic


Hour meter
19 BK 16
* * *
Fuse
Bus bar
Fuse block
6 O 16
1 B 16
13 BK 10
15 BK 16
Oil sender
Ignition switch
3 BK 10
2 B 16
Oil light
Distributor
7 Y 16
8 W 16
Coil
Y 16 17
G 16 5
Alternator light
Electric clutch
9 BR 16
10 BK 16
Temperature switch
Neutral lock switch
11 Y 12
21 B 4
Alternator
1 2
R
Spark-plug wires
Y 12 12
Heat light
16 Y 16
4 R 12
20 R 4
S
Battery
Electric clutch switch
22 BK 10
14 BK 10
18 BK 10
Starter solenoid
Main frame (ground)

*For accessories, wire gauge is indicated by the number following the wire color code.

INDEX	COLOR	GA.	DESCRIPTION
1	Blue	16	Fuse block to electric clutch
2	Blue	16	Clutch switch to fuse block
3	Black	10	Ignition switch "B" terminal to + terminal, starter
4	Red	12	Ignition switch "S" terminal to electric clutch switch
5	Green	16	Fuse block to electric clutch switch
6	Orange	16	Fuse block to coil + terminal
7	Yellow	16	Fuse block to alternator light
8	White	16	Oil light to oil sender switch
9	Brown	16	Heat light to +˚ temperature switch
10	Black	16	Alternator light to alternator #1 terminal
11	Yellow	12	Clutch switch to neutral lock switch
12	Yellow	12	Neutral lock switch to starter "S" terminal
13	Black	10	Ignition switch "I" terminal to fuse block
14	Black	10	Alternator #2 terminal to starter + terminal
15	Black	16	Ignition switch "A" terminal to + terminal, hour meter
16	Yellow	16	Alternator light to heat light
17	Yellow	16	Heat light to oil light
18	Black	10	Alternator + terminal to starter + terminal
19	Black	16	– terminal, hour meter to frame ground
20	Red	4	Battery + terminal to starter + terminal
21	Blue	4	Battery – terminal to engine ground
22	Black	10	Battery to frame ground

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Chassis Electrical Systems
Unit 7

Assignment Sheet 2—Determine Chassis-Electrical-System Service Specifications and Parts Requirements

Name ______________________________ Date ______________

Evaluation criteria	**Rating**
Directions have been followed.	______
Minimum of 85 percent of answers are correct.	______
Overall rating	______

Evaluator's comments ________________________________

____

____

Introduction

As noted in the previous assignment sheet, the use of electrical systems on power product equipment is becoming more common and more sophisticated. Along with these technical advances comes the use of a greater variety of parts and more critical specifications. For example, many of today's electrical systems employ electronic devices that have sensitivities measured in milliamps and millivolts—in thousandths of an ampere or volt. For these reasons, a technician's skills in identifying parts and specifications and applying those specifications are vitally important. In this assignment sheet, you will practice selecting parts and determining specifications for equipment that you are likely to service in your career as a power product equipment technician.

Exercise

Directions

Using resources available in your facility, determine the part numbers and specifications requested. Write your answers on the blanks provided under the questions.

1. What is the part number for a headlight replacement lamp for the following pieces of equipment?
    a. Gilson front-engine tractor

       Part number — ______________________________

    b. MTD Model 400 Series lawn tractor

       Part number — ______________________________

    c. Murray Model 36503 riding lawn mower

       Part number — ______________________________

Assignment Sheet 2

d. Roper Model L 863 riding lawn mower

Part number — ____________________

e. Wheel Horse Model A-70 riding lawn mower

Part number — ____________________

2. What size of fuse is used in each of the following circuits?

a. Sears-Craftsman: battery to ignition switch on electronic-start mowers

Fuse size — ____________________

b. Massey-Ferguson electric-starter riding lawn mowers: ignition switch to starter solenoid

Fuse size — ____________________

c. Murray Model 31501 riding lawn mower: key switch to starter solenoid

Fuse size — ____________________

d. Gilson rear-engine with electric starter: ignition switch to starter solenoid

Fuse size — ____________________

e. Hustler Model 295: fuse block for electric clutch

Fuse size — ____________________

3. In the chart below, write an "X" in the box under each switch listed that is found in the model of equipment given on the left.

Equipment	Seat switch	Clutch/brake switch	Neutral switch	Blade/mower switch
Ariens electric-start riding lawn mowers				
John Deere Model 57 riding lawn mowers				
Ford electric-start riding lawn mowers				
Roper Model 863 riding lawn mowers				
Wheel Horse electric-start riding lawn mowers				

Assignment Sheet 2

4. Some Wheel Horse garden tractors use the electromagnetic clutch shown in Figure 1 below for their PTO systems.

   a. If a failure occurs in the clutch system, one of the tests calls for checking the voltage across the clutch leads with the switch in the *ON* position. If the reading is zero, what is the probable cause?

      Probable cause — ______________________________

   b. What is the maximum normal reading expected in the voltage reading described in the previous question?

      Maximum voltage — ______________________________

   c. What is the normal resistance reading expected when measured across the clutch coil?

      Normal resistance reading — ______________________

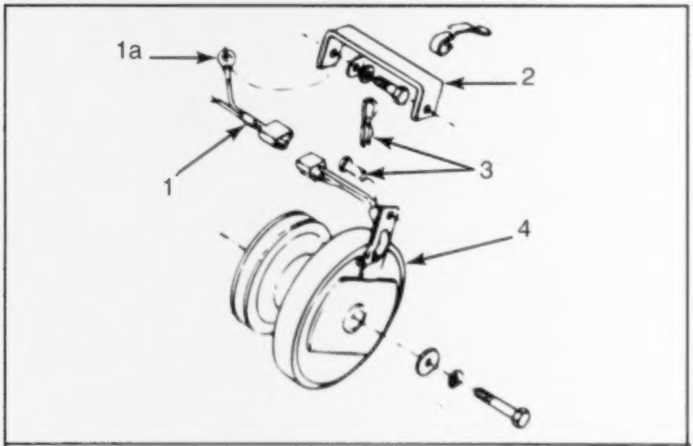
   d. To remove the clutch from the engine crankshaft, a bolt is used. What size bolt is required for clutches with part number 101473?

      Bolt size — ______________________________

   e. What is the part number for the kit to replace the field and bearing assembly?

      Part number — ______________________________

Figure 1: Wheel Horse electromagnetic PTO clutch



1. Cable and connector
1a. Ground lug
2. Mounting bracket
3. Clevis pin and cotter
4. Clutch assembly

Reproduced by permission of The Toro Company, Wheel Horse Division, Minneapolis, Minnesota.

Assignment Sheet 2

5. Some International Harvester and Cub Cadet tractors use an electric lift such as that shown in Figure 2 on the next page.

   a. What is the number of the electric motor in Figure 2?

      Part number — ______________________________

   b. The installation requires the use of Belleville washers and thrust washers on each side of the slip-clutch bushing. What is the correct installation configuration? (Circle the correct answer below.)

      Two Belleville washers, bushing, two thrust washers

      One thrust washer, one Belleville washer, bushing, one thrust washer, one Belleville washer

      One Belleville washer, one thrust washer, bushing, one thrust washer, one Belleville washer

      One Belleville washer, one thrust washer, bushing, one Belleville washer, one thrust washer

   c. What is the recommended torque for installation of the self-locking nut on the slip clutch and clevis?

      Torque — ______________________________

   d. If the motor fails electrically, what is the recommended service procedure?

      Service procedure — ______________________________

      ____

   e. Proper operation of the clutch allows slippage ______. (Circle each correct answer below.)

      Upon starting to lift

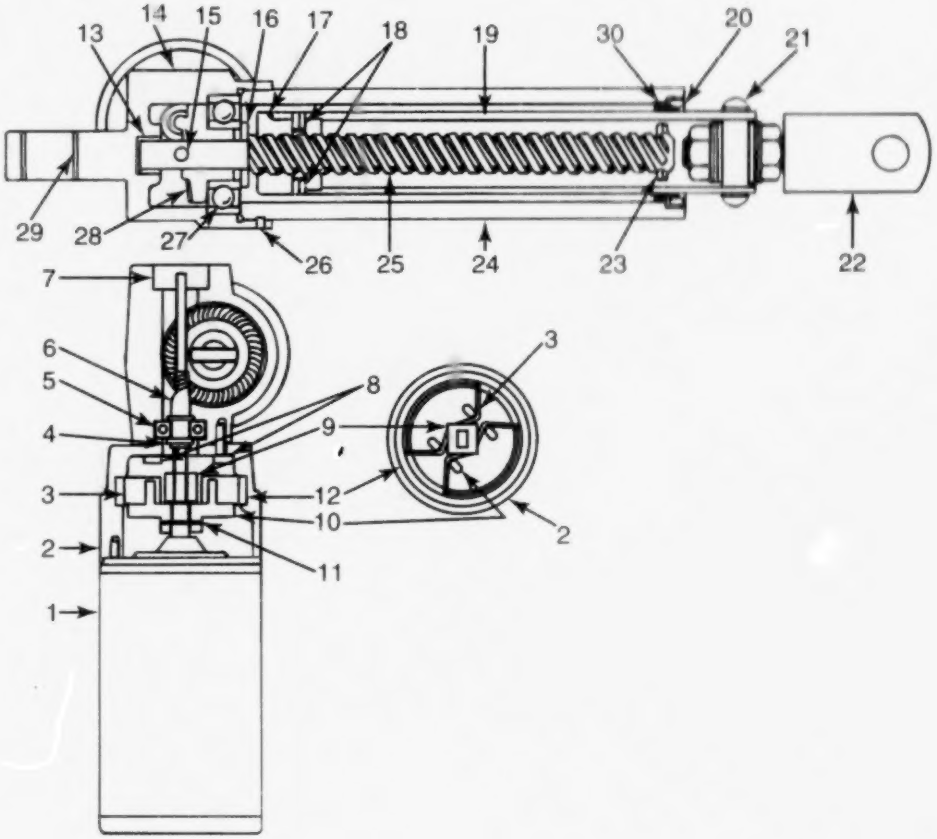
      During the lift

      At the fully raised position

      None of the above; slippage is not allowed

Assignment Sheet 2

Figure 2: International Harvester electric lift



Sectional view of electric lift unit used on some models

1. Motor
2. Adapter
3. Brake springs
4. Retaining ring
5. Pinion bearing
6. Pinion shaft
7. Pinion bushing
8. "Tap tite" screws
9. Brake cam
10. Drive coupling
11. Spring pin
12. Liner insert
13. Bushing
14. Housing
15. Drive pin
16. Washer
17. Lifting nut
18. Pins
19. Translating tube
20. Oil seal
21. Bushing screws
22. Clevis assembly
23. Stop pin
24. Outer tube
25. Lift screw
26. Set screw
27. Load bearing
28. Spiroid gear
29. Bushing
30. Guide bushing

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Chassis Electrical Systems
Unit 7

Job Sheet 1—Perform Routine Maintenance on Chassis Electrical Systems

Introduction

This job sheet covers the routine maintenance associated with chassis electrical systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect electrical components
- Service batteries
- Adjust belt tension for alternators and similar components

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1 and Assignment Sheet 2.

2. Watch your instructor's demonstration of performing routine maintenance on chassis electrical systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one chassis electrical system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a chassis electrical system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 1

Worksheet—Perform Routine Maintenance on Chassis Electrical Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 1

Worksheet—Perform Routine Maintenance on Chassis Electrical Systems

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Chassis Electrical Systems
Unit 7

Job Sheet 2—Repair Chassis Electrical Systems

Introduction

This job sheet covers the repair procedures associated with chassis electrical systems. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace electrical components, including bulbs, wiring, switches, gauges, etc.
- Overhaul electrical subsystems, including electrical motors
- Perform adjustments to return equipment to original specifications

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1 and Assignment Sheet 2.

2. Watch your instructor's demonstration of repairing chassis electrical systems and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one chassis electrical system. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses a chassis electrical system.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 2

Worksheet—Repair Chassis Electrical Systems

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 2

Worksheet—Repair Chassis Electrical Systems

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Chassis Electrical Systems
Unit 7

Job Sheet 3—Perform Routine Maintenance on Electrical Equipment Drives

Introduction This job sheet covers the routine maintenance associated with electrical equipment drives. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect equipment-drive components
- Lubricate mechanical components
- Tighten electrical connections
- Check system electrical values

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1 and Assignment Sheet 2.

2. Watch your instructor's demonstration of performing routine maintenance on electrical equipment drives and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one electrical equipment drive. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses an electrical equipment drive.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 3

Worksheet—Perform Routine Maintenance on Electrical Equipment Drives

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 3

Worksheet—Perform Routine Maintenance on Electrical Equipment Drives

---

Part B: **Performance evaluation**

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ______________________________

____

____

Chassis Electrical Systems
Unit 7

Job Sheet 4—Repair Electrical Equipment Drives

Introduction

This job sheet covers the repair procedures associated with electrical equipment drives. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace mechanical equipment-drive components, including gears, belts, U-joints, etc.
- Replace electrical equipment-drive components, including connectors, wiring, etc.
- Overhaul electrical equipment-drive subsystems, including motors
- Perform adjustments to return equipment to original specifications

Note: Many electric motors can be overhauled to some degree. As a minimum, brushes can be replaced. For some motors, the armature, bearings, and other components are replaceable. The service that can be performed depends on the recommendations of the motor manufacturer and the policies of your facility.

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1 and Assignment Sheet 2.

2. Watch your instructor's demonstration of repairing electrical equipment drives and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one electrical equipment drive. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses an electrical equipment drive.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 4

Worksheet—Repair Electrical Equipment Drives

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 4

Worksheet—Repair Electrical Equipment Drives

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Chassis Electrical Systems
Unit 7

Job Sheet 5—Perform Routine Maintenance on Electromagnetic Clutches

Introduction This job sheet covers the routine maintenance associated with electromagnetic clutches. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Inspect mechanical components
- Lubricate gears, bearings, and bushings
- Inspect electrical components
- Test electrical characteristics

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1 and Assignment Sheet 2.
2. Watch your instructor's demonstration of performing routine maintenance on electromagnetic clutches and any supporting media provided by your instructor.
3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one electromagnetic clutch. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.
4. Ask your instructor to provide you with power product equipment that uses an electromagnetic clutch.
5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.
6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.
7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 5

Worksheet—Perform Routine Maintenance on Electromagnetic Clutches

Name ______________________ Attempt number __________

Date ______________________

Part A: Pre-performance check

Job ______________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________

  Equipment model/type and code ______________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________

  Section/page number of procedure ______________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________

Job Sheet 5

Worksheet—Perform Routine Maintenance on Electromagnetic Clutches

---

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ____

____

____

Chassis Electrical Systems
Unit 7

Job Sheet 6—Repair Electromagnetic Clutches

Introduction

This job sheet covers the repair procedures associated with electromagnetic clutches. You will accomplish these tasks by following the appropriate procedures in the manufacturer's service manual. While the specific procedures will depend on the equipment design and manufacturer's processes, the general tasks that may be performed under this procedure include

- Replace clutch components, including magnetic coil, wiring, bushings, etc.
- Overhaul clutch subsystems, including actuators, linkages, electrical components, etc.
- Perform adjustments to return equipment to original specifications

Procedure

1. Study all of the objectives in the information sheet and complete Assignment Sheet 1 and Assignment Sheet 2.

2. Watch your instructor's demonstration of repairing electromagnetic clutches and any supporting media provided by your instructor.

3. Review the following worksheet associated with this job sheet. You may be required to accomplish this job sheet for more than one electromagnetic clutch. Check with your instructor, and obtain a copy of the worksheet for each attempt that will be required.

4. Ask your instructor to provide you with power product equipment that uses an electromagnetic clutch.

5. Complete the pre-performance check (Part A) on the worksheet and receive your instructor's signed approval for the service information you have located and the equipment/materials you have listed for performing the procedure on the equipment assigned.

6. Review the evaluation criteria listed in the performance evaluation (Part B) on the worksheet.

7. Using the instructor-approved service information and equipment/materials list, perform the appropriate procedure. Your instructor will rate your performance using the evaluation criteria listed in the performance evaluation on the worksheet.

Job Sheet 6

Worksheet—Repair Electromagnetic Clutches

Name ______________________________ Attempt number __________

Date ______________________________

Part A: Pre-performance check

Job ______________________________

- Complete the following information concerning the assigned equipment.

  Equipment brand ______________________________

  Equipment model/type and code ______________________________

  ____

- Complete the following service-manual information.

  Service-manual title ______________________________

  Section/page number of procedure ______________________________

- List type and number of replacement parts.

- List special equipment/materials required for procedure.

Instructor's signature ______________________________

Job Sheet 6

Worksheet—Repair Electromagnetic Clutches

Part B: Performance evaluation

Evaluation criteria	**Rating**
Correct procedures identified for assigned equipment.	______
Procedures completed correctly.	______
Proper tools used correctly.	______
Safety precautions observed.	______
Service meets specifications.	______
Clean-up and follow-up actions adequate.	______
Overall rating	______

Evaluator's comments ______________________________

____

____

2

Power Product Equipment Technician Series

Theory and Principles of Engine Operation

Section A: Orientation

Section B: Basic Engine Theory and Operation

Engine Systems and Service

Section A: Engine Systems

Section B: Engine Overhaul

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